COOPERATIVE RESEARCH PROGRAM ADDRESSING FINFISH BYCATCH IN THE GULF OF MEXICO AND SOUTH ATLANTIC SHRIMP FISHERIES:

A REPORT TO CONGRESS

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April 1995

U.S. DEPARTMENT OF COMMERCE
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Secretary

National Oceanic and Atmospheric Administration
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Under Secretary for Oceans and Atmosphere

National Marine Fisheries Service
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The Honorable Larry Pressler
Chairman, Committee on Commerce,
    Science, and Transportation
United States Senate
Washington, D.C.   20510

Dear Mr. Chairman:

I am pleased to submit the Report to Congress on the Cooperative Research Program Addressing Finfish Bycatch in the Gulf of Mexico and South Atlantic Shrimp Fisheries. This report and the research it summarizes are required under The Fishery Conservation Amendments of 1990 (Public Law 103-206; section 110(c)), which amended the Magnuson Fishery Conservation and Management Act (16 U.S.C. 1854). As amended, section 304(g) of the Magnuson Act directs the Secretary to conduct a 3-year research program assessing the impact of the incidental harvest by the shrimp trawl fishery on fishery resources within the authority of the South Atlantic and Gulf of Mexico Fishery Management Councils. It also directs the Secretary to establish a program to design and evaluate technological approaches to reduce the mortality of these incidentally harvested fishery resources.

The National Marine Fisheries Service has conducted this research and development program in cooperation with the Councils, coastal states, commercial and recreational fishing industries, and the conservation and academic communities. February 1995 marked the end of the third year of the program. The enclosed report summarizes program progress to date and agency plans for its completion. It satisfies the requirements of Public Law 103-206 for a report to Congress on program results.

Sincerely,

Ronald H. Brown

Enclosure

The Honorable Don Young
Chairman, Committee on Resources
House of Representatives
Washington, D.C.   20515

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Enclosure

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Forward

The Fishery Conservation Amendments of 1990 (Public Law 101-627, Section 110(c) amended the Magnuson Fishery Conservation and Management Act (16 U.S.C. 1854) to require the Secretary of Commerce (Secretary) to conduct a 3-year research program to determine the impact of incidental harvest by shrimp trawlers on federally managed fishery resources found along the Nation's south Atlantic and Gulf of Mexico coasts.

The Secretary was also required to establish a cooperative program to design and evaluate approaches for reducing the mortality of these incidentally harvested fishery resources. Upon its completion, Congress required the Secretary to submit a detailed report on research program findings.

The National Marine Fisheries Service (NMFS), acting on behalf of the Secretary, has worked diligently to respond fully to Congressional mandates by implementing a shrimp trawl bycatch research program that is scientifically valid and inclusive of affected and interested parties. February 1995 will mark the completion of the third year of this intensive research effort —but not the completion of the entire research program. Therefore, this report is being submitted to apprise Congress of progress made to date and plans for completing this program.

Acknowledgments

Executive Summary

This report responds to Congressional requirements imposed pursuant to the Magnuson Fishery Conservation and Management Act (Magnuson Act) as amended in 1990.

Section 304(g) of the Magnuson Act specifies that the Secretary of Commerce ". . . shall, after consultation with the Gulf of Mexico Fishery Management Council and the South Atlantic Fishery Management Council, establish by regulation a 3-year program to assess the impact on fishery resources of incidental harvest by the shrimp trawl fishery within the authority of such Councils." It further states that ". . . the Secretary shall, in cooperation with affected parties, commence a program to design, and evaluate the efficacy of, technological devices and other changes in fishing technology for the reduction of incidental mortality of nontarget fishery resources in the course of shrimp trawl fishing activity."

The National Marine Fisheries Service, acting on behalf of the Secretary, has attempted to respond fully to Congress's mandate for an Incidental Harvest Research Program. In doing so, two guiding principles have been applied consistently.

First, priority attention has been given to ensure the research program is scientifically sound in its design and implementation. To this end, NMFS' Southeast Regional Office and Fisheries Science Center jointly developed and published a document entitled "Shrimp Trawl Bycatch Research Requirements" in November, 1991 (NMFS, 1991). This document established scientifically sound protocols for: 1) conducting onboard shrimp trawl bycatch characterization research, 2) developing and testing bycatch reduction devices (BRDs), and 3) evaluating various bycatch management options. These scientific protocols were subjected to peer review by an industry-organized panel of researchers and statisticians and, upon approval, became the scientific foundation of the Bycatch Research Program.

Second, because the shrimp trawl bycatch issue has profound implications for numerous user groups, care has been taken to involve affected parties in this important research program. To accomplish this, NMFS entered into several cooperative agreements with the Gulf and South Atlantic Fisheries Development Foundation, Inc. (Foundation) to organize a 34-member Finfish Bycatch Steering Committee to guide the development and implementation of the bycatch research plan. Included on the Steering Committee are representatives of the commercial and sport fishing industry, the conservation community, state fishery management agencies, the Gulf and the Atlantic States Marine Fisheries Commissions, the Gulf and the South Atlantic Fishery Management Councils, Sea Grant programs, universities, and NMFS. In addition, a 15-member Technical Review Panel and 8-member Gear Review Panel were established to advise the Steering Committee. Working together, these diverse groups developed and published "A Research Plan Addressing Finfish Bycatch in the Gulf of Mexico and South Atlantic Shrimp Fisheries" (Plan) (Hoar et al, 1992) and have been involved intimately in its implementation.

In the Plan, the Finfish Bycatch Steering Committee recommended a comprehensive 4-year program including 44 research projects requiring an estimated total investment of nearly $15 million. Collectively, these priority research and development projects were designed and organized to address the following eight major program objectives:

1. Update and expand bycatch estimates temporally and spatially including offshore, nearshore, and inshore waters.

2. Improve assessments of the status and condition of fish stocks significantly impacted by shrimp trawl bycatch.

3. Identify, develop, and evaluate gear options for reducing bycatch in the Gulf of Mexico and South Atlantic shrimp fisheries.

4. Identify, develop, and evaluate non-gear and tactical fishing options for reducing shrimp fishery finfish bycatch.

5. Evaluate the biological, sociological, and economic impacts of management options to reduce shrimp fishery finfish bycatch.

6. Provide continued cooperative oversight of research plan implementation and develop an information transfer and education program for commercial shrimp fishermen and other parties affected by finfish bycatch.

7. Evaluate the magnitude and distribution of fishing mortality on current and potential bycatch species by sources other than shrimp trawl fishing activity.

8. Develop and operate a standardized data management system for the cooperative research program.

Thanks to the combined cooperative efforts of many government and private organizations and individuals, significant progress has been made towards achieving Plan objectives, and with substantially fewer dollars than anticipated. Approximately, $7.4 million has been invested in 51 projects during the first 3 years of this program compared with $11.7 million in projected expenditures for this period. Of this $7.4 million, roughly 84 percent has been directed at bycatch characterization and BRD development. Spending on program planning and management, social and economic research, and information education activities has accounted for 4.5 percent, 8.1 percent, and 3 percent of total expenditures, respectively. Appendix II provides a listing of completed and ongoing federally funded bycatch research projects. Accomplishments regarding database management, stock assessment, and non-gear management research objectives have been supported primarily with NMFS' base funds, as have NMFS contributions to overall program management. Significant undocumented expenditures made by states, the shrimp industry, and other cooperators are recognized.

Some of the more significant features and accomplishments of this program merit emphasis:

- ◄ The program continues to be an inclusive cooperative effort with strong participation by the shrimp industry, states, sport fishing interests, universities, and the conservation community.

- ◄ There has been strict adherence to stringent scientific protocols by all cooperators.

- ◄ Available resources from many sources have been used to reduce the need for "new" funding.

- ◄ Bycatch characterization is nearly complete.

- ◄ Characterization data are already being incorporated into stock assessments for several key species.

- ◄ Social and economic impacts are being addressed.

- ◄ The bycatch reduction performance of grid-type Turtle Excluder Devices (TEDs) has been evaluated and research to evaluate soft TEDS is underway.

- ◄ Several BRDs are being commercially tested that meet program performance criteria for red snapper bycatch reduction, with minimal shrimp loss.

Building on these accomplishments, research program emphasis will shift over the coming months in several ways. Bycatch characterization data will continue to be collected, but mainly as a secondary activity done in conjunction with larger scale commercial testing of BRDs. The Gear Review Panel will continue to actively search for new BRD designs capable of meeting program finfish exclusion and shrimp retention goals. The Panel also will be reviewing TED bycatch reduction evaluation results and developing procedures for certification of BRDs.

Researchers and managers will intensify efforts to analyze characterization data to quantify bycatch and associated mortality for species of concern, and to identify alternative bycatch management strategies. In this regard, scientific panels likely will be convened to review the results of these analyses, and to address any continuing concerns about the research program. Associated with this, social and economic data collection and modeling efforts will proceed to support the effective evaluation of bycatch management proposals.

Last, more formal and intensive information and education efforts will be implemented to expedite the broad dissemination of research findings and the transfer of bycatch reduction technology to the fishing community and other interested and affected parties. Timely information dissemination will be crucially important to resolving this issue.

About This Report

This report deals with one of the most significant marine fisheries issues of the 1990s — shrimp trawl bycatch.

Specifically, its purpose is to update members of Congress and other interested parties on progress made by the Secretary in developing and implementing a cooperative shrimp trawl bycatch research program for the southeastern United States. Congressional mandates for this regional research effort were outlined in the Magnuson Act, as amended in 1990.

While not complete, significant progress has been made through this research program in addressing the complex bycatch issue. Excellent, cooperative working relationships have been established among the many and diverse government, industry, and public parties interested in resolving the shrimp trawl bycatch problem. The balance of this report describes the bycatch problem, reviews Congressional mandates for the program, and highlights the Secretary's response to these mandates, including a brief review of significant accomplishments relative to each research program objective.

The Problem

Since the late 1940s, technological advances have revolutionized fishing vessels, fishing gear, navigational equipment, and fishing techniques. These advancements have enabled commercial and recreational fishermen to catch effectively the fish they seek thus placing tremendous harvest pressure on many stocks. Many of these fisheries target a single species or groups of species (e.g., reef fish) and employ the most efficient fishing methods and gear available, but they are seldom 100 percent selective. As a result, in most commercial and recreational fisheries worldwide, an incidental capture of non-target species and age groups occurs. This incidental harvest is termed bycatch.

In some fisheries, bycatch is commercially valuable and is landed along with the target species. In other fisheries, bycatch is non-marketable or illegal to land and is therefore discarded with high mortality rates after target species have been removed. While discarded bycatch is usually of little economic importance to these fisheries, the mortality of directly affected species is not without consequence. It can adversely affect the population size and structure of impacted stocks, reduce the availability of bycatch species to other fishermen who may target them in other fisheries, and result in fundamental changes in ecosystem energy flows.

Since the mid-1970s, concern over bycatch in the Gulf of Mexico and South Atlantic shrimp fisheries has intensified among state and federal fishery managers, conservationists, commercial and recreational fishermen, and the public. Concerns initially surfaced over the incidental capture of endangered or threatened sea turtles. Substantial progress, however, is being made reducing sea turtle mortalities through the required use of certified TEDs.

More recently, concern over shrimp trawl bycatch has broadened to include the incidental catch of finfish and other living marine resources. Concern over finfish bycatch is being expressed intensely and globally, and for several important reasons:

- An increasing world demand for protein, linked with a growing realization that coastal ocean resources are finite and under stress, has focused national attention on the need to minimize waste in all fisheries, including valuable shrimp fisheries.

- Declining landings for many species of marine finfish, shellfish, and crustaceans have precipitated the imposition of state and federal catch restrictions to maintain or rebuild depleted fish stocks. As a matter of equity, sport and commercial fishermen are reluctant to accept regulation of their directed fishing activities if management measures are not also imposed to reduce significant incidental fishing mortality.

- Research findings in the 1980s and early 1990s revealed that bycatch discards in the Gulf of Mexico and southeastern Atlantic shrimp fisheries were indeed significant. While croaker, seatrout, porgies, spot, and other non-federally managed groundfish species accounted for the larger share of bycatch, federally-managed species such as red snapper, king mackerel, Spanish mackerel, and sharks were also represented.

- Stock assessments in the early 1990s indicated some finfish species taken as bycatch in the shrimp fishery were under severe stress and would not recover quickly unless shrimp bycatch was reduced. Red snapper in the Gulf of Mexico and weakfish in the South Atlantic were two notable examples.

Concern over red snapper populations in the Gulf of Mexico brought the shrimp trawl bycatch issue into focus and precipitated the development and implementation of this cooperative bycatch research program. In 1989, a red snapper stock assessment revealed that the Gulf stock was at a very low level and that directed and incidental harvest would have to be severely restricted to allow for stock rebuilding. Notably, data showed that over 90 percent of the fishing mortality on age 0 and age 1 red snapper was attributed to shrimp trawling (Goodyear, 1990). Managers agreed that this source of mortality would have to be significantly reduced in order to rebuild red snapper stocks within the time frame established by the Gulf of Mexico Fishery Management Council (Council) without halting all directed commercial and recreational red snapper fisheries.

In 1990, the Council considered a 3-month closure of the Gulf shrimp fishery to protect juvenile red snapper. This proposal responded to concerns expressed by commercial and recreational red snapper fishermen who believed shrimpers needed to share the burden of regulations required to rebuild red snapper populations. However, subsequent analysis of the proposed closure (Nichols et al, 1990)

indicated that it would likely have little benefit, particularly if shrimping effort shifted to other periods. This realization motivated the Council to begin searching for other management approaches that might be effective in reducing the bycatch of small juvenile red snapper in shrimp trawls. During these discussions, many parties raised concerns about the adequacy of shrimp bycatch estimates and the potential economic impacts that would likely result from proposed management measures.

The Mandate from Congress

During the 1990 reauthorization of the Magnuson Act, concerns over bycatch manifested themselves in an amendment mandating the Secretary to initiate an "Incidental Harvest Research Program." Through Section 304(g) of the Act, Congress communicated the following charge to the Secretary:

101-627, Section 304(g) INCIDENTAL HARVEST RESEARCH.—

(1) Within 9 months after the date of enactment of the Fishery Conservation Amendments of 1990, the Secretary shall, after consultation with the Gulf of Mexico Fishery Management Council and South Atlantic Fishery Management Council, establish by regulation a 3-year program to assess the impact on fishery resources of incidental harvest by the shrimp trawl fishery within the authority of such Councils.

(2) The program established pursuant to paragraph (1) shall provide for the identification of stocks of fish which are subject to significant incidental harvest in the course of normal shrimp trawl fishing activity.

(3) For stocks of fish identified pursuant to paragraph (2), with priority given to stocks which (based upon the best available scientific information) are considered to be overfished, the Secretary shall conduct —

(A) A program to collect and evaluate data on the nature and extent (including the spatial and temporal distribution) of incidental mortality of such stocks as a direct result of shrimp trawl fishing activities;

(B) An assessment of the status and condition of such stocks, including collection of information which would allow the estimation of life history parameters with sufficient accuracy and precision to support sound scientific evaluation of the effects of various management alternatives on the status of such stock; and

(C) A program of data collection and evaluation for such stocks on the magnitude and distribution of fishing mortality and fishing effort by sources of fishing mortality other than shrimp trawl fishing activity.

(4) The Secretary shall, in cooperation with affected interests, commence a program to design, and evaluate the efficacy of, technological devices and other changes in fishing technology for the reduction of incidental mortality of nontarget fishery resources in the course of shrimp trawl fishing activity. Such program shall take into account local conditions and include evaluation of any reduction in incidental mortality, as well as any reduction or increase in the retention of shrimp in the course of normal fishing activity.

(5) The Secretary shall, upon completion of the programs required by this subsection, submit a detailed report on the results of such programs to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Merchant Marine and Fisheries of the House of Representatives.

(6) (A) Except as provided in this paragraph, the Secretary may not implement any measures under this Act to reduce incidental mortality of nontarget fishery resources in the course of shrimp trawl fishing which would restrict the period during which shrimp are harvested or would require the use of any technological device or other change in fishing technology.

(B) The prohibition contained in subparagraph (A) shall cease on January 1, 1994.

(C) This paragraph does not apply to any law or regulation in effect on the date of enactment of this paragraph, nor does it limit in any way the Secretary's authority to take action, including any limitation on entry permitted by this Act, for the conservation and management of the shrimp fishery resource.

NMFS, acting on behalf of the Secretary, has attempted to respond fully to Congressional mandates for an incidental harvest research program. In doing so, two guiding principles have been consistently applied.

First, priority attention has been given to ensure that the research program is scientifically sound in its design and implementation. To this end, NMFS' Southeast Regional Office and Fisheries Science Center jointly developed and published a document entitled "Shrimp Trawl Bycatch Research Requirements" (NMFS, 1991). This document established scientific protocols for: conducting onboard shrimp trawl bycatch characterization research, developing and testing bycatch reduction devices (BRDs), and evaluating various bycatch management options. These protocols were subjected to peer review by an industry-organized panel of researchers and statisticians and, upon approval, became the scientific foundation of the Bycatch Research Program.

Second, because the shrimp trawl bycatch issue has profound implications for numerous user groups, care has been taken to involve all affected parties in the research program. To this end, NMFS entered into several cooperative agreements with the Foundation to organize and utilize a 34-member Finfish Bycatch Steering Committee to guide the development and implementation of the bycatch research plan. Included on the Steering Committee are representatives of the commercial and sportfishing industries, the conservation community, state fishery management agencies, the Gulf and the Atlantic States Marine Fisheries Commissions, the Gulf and the South Atlantic Fisheries Management Councils, Sea Grant programs, universities, and NMFS (see Appendix I). In addition, a 15-member Technical Review Panel and 8-member Gear Review Panel were established to advise the Steering Committee.

Working together, these diverse groups developed and published "A Research Plan Addressing Finfish Bycatch in the Gulf of Mexico and South Atlantic Shrimp Fisheries" (Hoar et al, 1992) and have been involved intimately in its implementation. During its last meeting in October 1994, the Steering Committee received detailed progress reports from state, university, federal, and industry researchers on all aspects of the research program and offered guidance on future program activities.

Ultimately, the goal of the finfish bycatch research program (Program) is to assess the impact of incidental shrimp trawl bycatch on federally managed fishery resources and thus provide fishery managers information needed to judiciously manage finfish bycatch in the Gulf and South Atlantic shrimp fisheries.

To meet this goal, researchers have implemented a practical and cooperative program to determine when, where, and to what extent bycatch shows up in commercial shrimp trawls and to develop the means to substantially reduce bycatch with little or no shrimp loss. The Program also seeks to maximize the social, cultural, and economic benefits of bycatch management approaches across all affected fisheries. Information, education, and technology transfer efforts are an integral and important part of this research program.

The Plan organizes priority research and development activities under the following eight major program objectives, each with associated tasks and projects:

1. Update and expand bycatch estimates temporally and spatially including offshore, nearshore, and inshore waters.

2. Improve assessments of the status and condition of fish stocks significantly impacted by shrimp trawl bycatch.

3. Identify, develop, and evaluate gear options for reducing bycatch in the Gulf of Mexico and South Atlantic shrimp fisheries.

4. Identify, develop, and evaluate non-gear and tactical fishing options for reducing shrimp fishery finfish bycatch.

5. Evaluate the biological, sociological, and economic impacts of management options to reduce shrimp fishery finfish bycatch.

6. Provide continued cooperative oversight of research plan implementation and develop an information transfer and education program for commercial shrimp fishermen and other parties affected by finfish bycatch.

7. Evaluate the magnitude and distribution of fishing mortality on current and potential bycatch species by sources other than shrimp trawl fishing activity.

8. Develop and operate a standardized data management system for the cooperative research program.

A comprehensive 4-year work program was outlined in the Plan with estimated funding requirements arrayed by objectives totaling nearly $15 million. While some of the recommended research built on current activities, much of it was new. It did, however, represent the best estimate of the costs and requirements for fulfilling the Congressional mandates.

		Year		
Research Objectives	1	2	3	4
Bycatch Characterization	$1325	$2475	$2265	$2165
Bycatch Species Assessment	0	240	410	360
Gear Modification	720	615	615	545
Non-Gear Management Options	125	100	30	0
Impacts	560	660	410	10
Information/Education	243	280	280	100
Other Sources of Mortality	0	90	40	0
Data Base Management	0	70	70	70
TOTAL	$3043	$4530	$4120	$3250

Significant progress has been made to date towards achieving Plan objectives, and with substantially fewer dollars than anticipated. As Table 1 depicts, approximately, $7.4 million has been invested during the first 3 years of this program compared with $11.7 million in projected expenditures for this period. Approximately 84 percent of current program expenditures have been directed at bycatch characterization and BRD development. Spending in these two priority areas relative to other program expenditures is illustrated in Figure 1 and documented in Appendix II, which lists all completed and ongoing federally funded bycatch research projects. Accomplishments regarding database management, stock assessment, and non-gear management research objectives have been supported primarily with NMFS base funds, as have NMFS contributions to overall program management. The significant expenditures made by states, the shrimp industry, and other cooperating organizations, especially in the form of in-kind contributions and matching funds for grants are not documented for this report.

Table 1:
Directed Federal Funding
Expenditures on Bycatch
Research by Fiscal Year
(Thousands)

Source	FY 92	FY 93	FY 94
NMFS	$1,240	$972	$675
Salton-Kennedy	840	724	840
MARFIN	494	487	500
G&SAFDF Appropriation			665
TOTAL	$2,574	$2,183	$2,680

Figure 1:
Percent Total Bycatch
Program Expenditures by
Category

BRD Development
(53.4%)

Program
Planning/Mgmt
(4.5%)

Social & Economic
(8.1%)

Information/Education
(3%)

Bycatch Characterization
(31%)

Total Spent - $7.4 Million
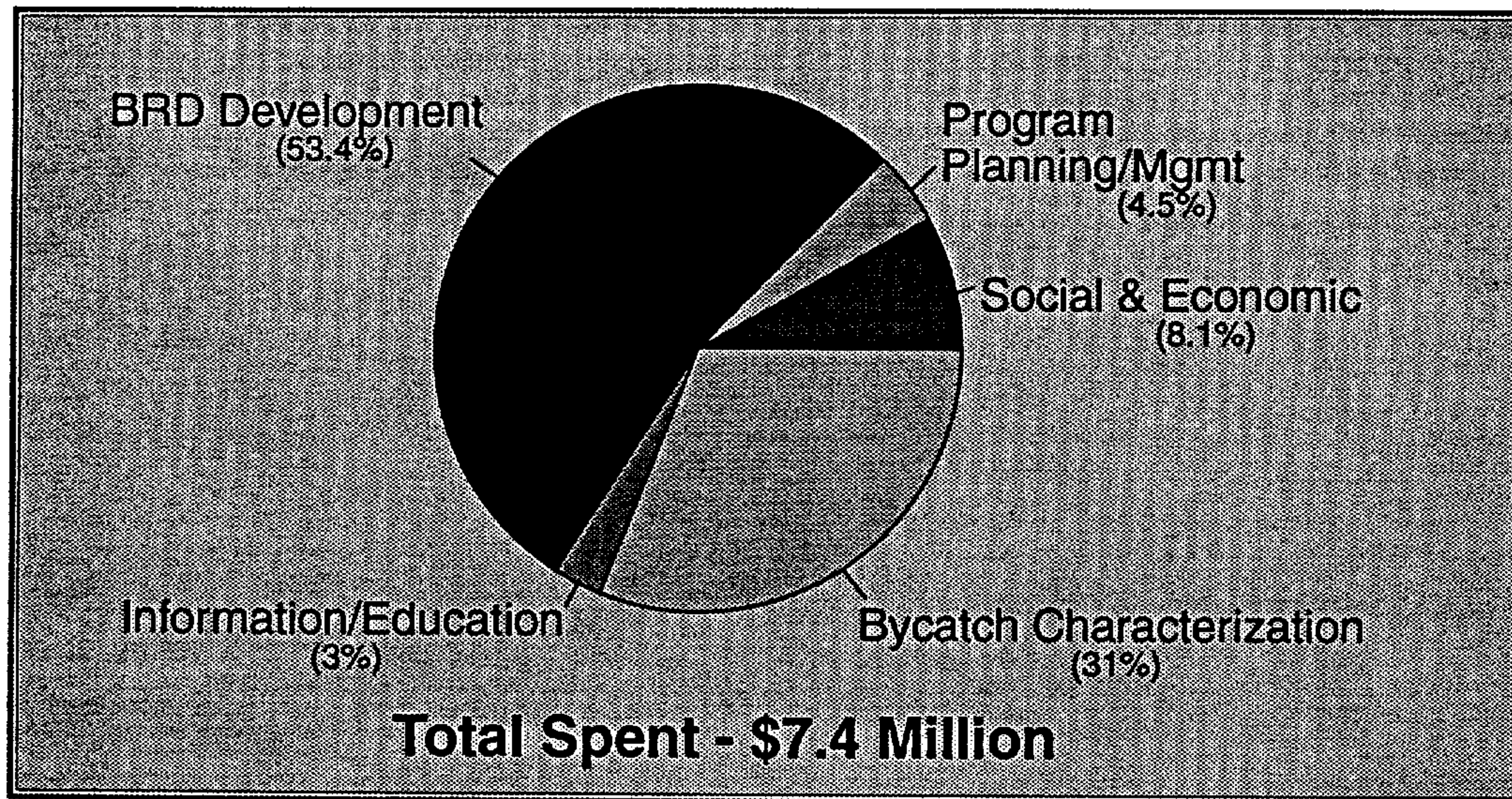
Program Accomplishments

The following sections provide a brief summary of the more significant accomplishments made with respect to each of the eight major program objectives.

Discussions under each objective include a brief statement of essential program needs, a list of research actions required to address these needs, and a descriptive overview of significant accomplishments to date. **The intent here is to demonstrate program responsiveness to Congressional mandates and notable progress, not to provide an exhaustive discussion of detailed program findings.** Technical reports, which are better suited for relaying detailed program findings, are being prepared as research is completed.

Program Objective I

Shrimp Trawl Bycatch Characterization

Program Needs

Recent estimates of the nature and magnitude of shrimp fishery bycatch were based on the use of a General Linear Model (GLM) which uses stock abundance information from recent resource survey cruises and current estimates of total shrimp effort to expand and update older bycatch observations from commercial trawlers. Questions regarding the reliability of these updated estimates have made it necessary to collect new bycatch data through surveys conducted aboard shrimp trawlers during normal fishing operations. Because bycatch data are critical to the completion of most other research program activities, it is imperative that they be collected in ways that ensure their integrity and validity.

Research Actions:

(1) Conduct a voluntary observer program using trained NMFS and non-NMFS observers. Program includes vessel insurance and compensation for cooperating vessels.

(2) Using a stratified sampling approach indexed to shrimping effort, deploy observers throughout the fleet to document bycatch during normal fishing operations using standard data collection protocols.

(3) Enter all data into a common data base managed by NMFS Southeast Fisheries Science Center's Galveston Laboratory.

(4) Analyze characterization data, and make data and analyses available to other program researchers and fishery managers.

Significant Accomplishments

Characterization Survey Design and Implementation

Through long-term monitoring of the shrimp fishery, NMFS has developed an extensive database documenting spatial and temporal patterns of shrimping effort and catch. In the 1970s and early 1980s, a considerable amount of information on shrimp bycatch was generated, some of which resulted from major at-sea research efforts to document the incidental take of sea turtles (Blomo and Nichols, 1974; Chittenden and McEachran, 1975; Drummond, 1976; Pavella, 1977; Warren, 1981; Pellegrin et al, 1981; Bryan et al, 1982; Guillory and Hutton, 1982; Nichols et al, 1987 and 1990). However, because new bycatch information has not been collected since then, bycatch estimates have been updated periodically through the use of a GLM (Nichols et al, 1987 and 1990). This approach recognizes that the extent to which a particular species is caught in a shrimp trawl depends chiefly on its overall abundance in the ecosystem, the degree to which it inhabits areas in which trawling activity occurs, the total amount of shrimping effort exerted in a given area over time, the type of trawl gear used, and the behavioral adaptations of the species which make it vulnerable, or not, to trawl capture. The model

uses recent fishery resource survey cruise and shrimp effort data to update earlier bycatch estimates.

Because of expressed concerns about existing estimates (e.g., their age and the fact they were collected before TEDs were required) and Congressional mandates for new bycatch estimates, program researchers designed and have conducted an extensive bycatch characterization survey. This survey has involved the deployment of observers aboard cooperating commercial shrimp vessels to document bycatch in normal fleet operations (NMFS, 1992a). Observers have also collected bycatch information by sampling control nets during the testing of bycatch reduction devices (NMFS, 1992b). In both cases, due to requirements mandated by the Endangered Species Act, the industry standard or control net is a trawl incorporating a certified TED.

Figure 2:
Bycatch Characterization
Research Sampling
Coverage (2/92 - 8/94)

TOTAL
2,549 Sea Days
215 Trips
3,296 Tows

S. Atlantic
393 Sea Days
63 Trips
679 Tows

Gulf
2,156 Sea Days
152 Trips
2,617 Tows
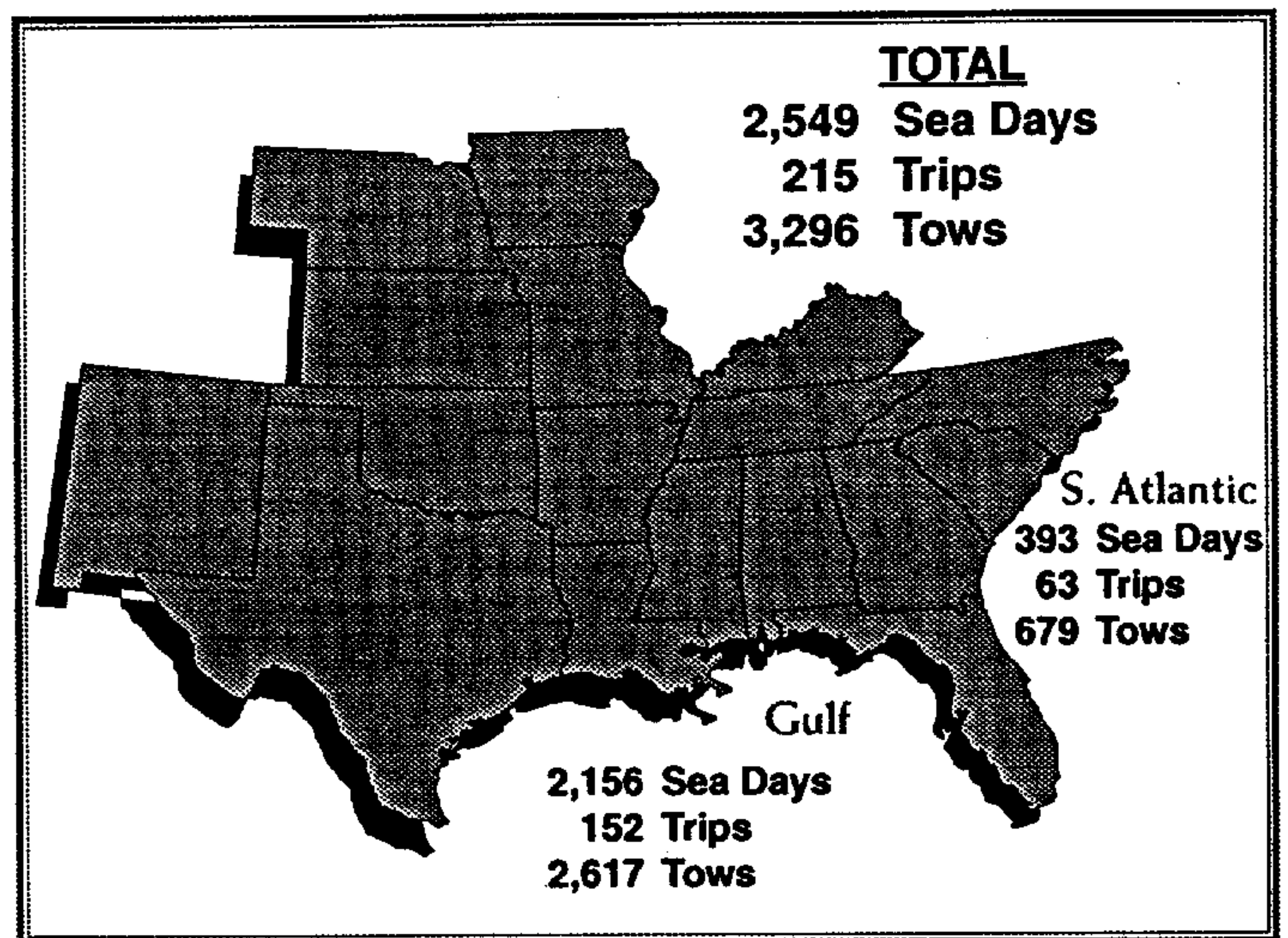
As Figure 2 reflects, a total of 2,549 sea days of sampling were completed between February 1992 and September 1, 1994, a level of effort considered generally sufficient by program managers to address bycatch characterization information needs. Of note, roughly 56 percent of these sampling days was completed by observers deployed by the Foundation and Texas Shrimp Association. The success of this effort has hinged on several critical factors:

1. Onboard sampling protocols developed by NMFS for this survey were subjected to peer review by an industry assembled panel of survey experts and statisticians.

2. Characterization sampling was conducted by NMFS and non - NMFS (primarily Foundation and Texas Shrimp Association) observers, all of whom received the same training and utilized approved data collection protocols.

3. Cooperating vessel owners were provided supplemental insurance coverage and reimbursed for additional expenses they incurred as a result of having an observer aboard e.g., meals). The Foundation and Texas Shrimp Association have done an outstanding job securing the cooperation of shrimp vessels and administering associated vessel insurance and observer support programs.

4. Cooperation from the commercial shrimp industry has been exemplary, with over 80 vessels voluntarily carrying observers on trips lasting from 1 to 56 days.

Cooperation from the shrimp fleet has enabled observers to generate a comprehensive bycatch database that reflects offshore shrimping operations in the South Atlantic and Gulf of Mexico. In this context, offshore refers to areas seaward of the shoreline or barrier islands and does not include "inside" waters (e.g., bays, estuaries, and sounds). By comparing bycatch characterization sampling coverage with historical shrimp catch and effort distributions, researchers have determined that very few important offshore fishing areas were missed.

Along with catch-per-unit-of-effort (CPUE) data, information was collected for each sampled tow regarding environmental conditions, trawl/TED gear, fishing operations, and vessel characteristics (NMFS, 1992a). All data have been assembled into one database at the NMFS Galveston Laboratory and are being analyzed to discover how bycatch changes as a function of area, depth, season, and vessel/gear combinations. Current CPUE data are being incorporated into the GLM to produce estimates of total bycatch. Access to this extensive bycatch characterization database is being provided to program researchers to complete other program tasks and to fishery managers for use in state and federal management programs.

Characterization Survey Results

Analysis of characterization data reveals important insights about bycatch in the South Atlantic and Gulf of Mexico shrimp fisheries. For presentation purposes, the data have been summarized into selected area, depth, and season categories. As portrayed in Figure 3, a trawl pulled for one hour in the South Atlantic area captures on average 1214 organisms weighing nearly 64 pounds. Commercial shrimp accounts for 29 percent of the total catch by number and 20 percent, by weight. Finfish, on the other hand, constitutes 46 percent of the catch by number and 47 percent by weight. Thus, the ratio of finfish to shrimp caught for each hour of trawling is 1.6 : 1 by number, or 2.3 : 1 by weight.

Figure 3:
Average Shrimp Trawl
Catch Per Hour in the
South Atlantic
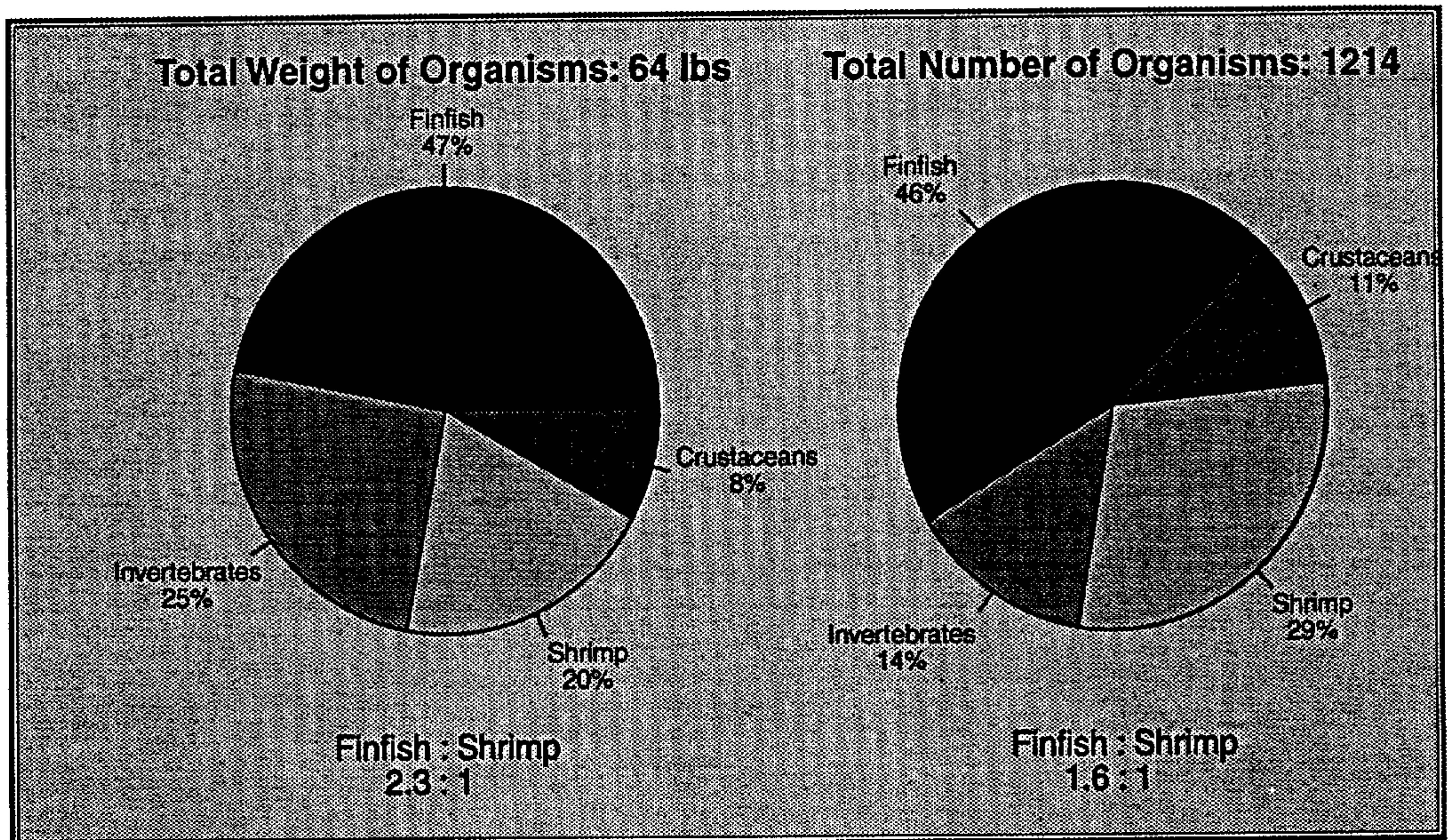
The top 10 species caught per hour by weight in a typical South Atlantic trawl make up 74 percent of the total biomass and normally include cannonball jellyfish (14 percent), white shrimp (9 percent), spot (9 percent), Atlantic menhaden (9 percent), other jellyfish (8 percent), brown shrimp (8 percent), Atlantic croaker (6 percent), southern kingfish or whiting (4 percent), blue crab (4 percent), and star drum (3 percent). The top ten species caught per hour by number in the same trawl make up 71 percent of the total and include brown shrimp (13 percent), spot (10 percent), white shrimp (10 percent), Atlantic menhaden (8 percent), cannonball jellyfish (6 percent), star drum (6 percent), pink shrimp (6 percent), Atlantic croaker (5 percent), other jellyfish (4 percent), and blue crab (3 percent).

Figure 4:
Average Shrimp Trawl
Catch Per Hour in the
Gulf of Mexico
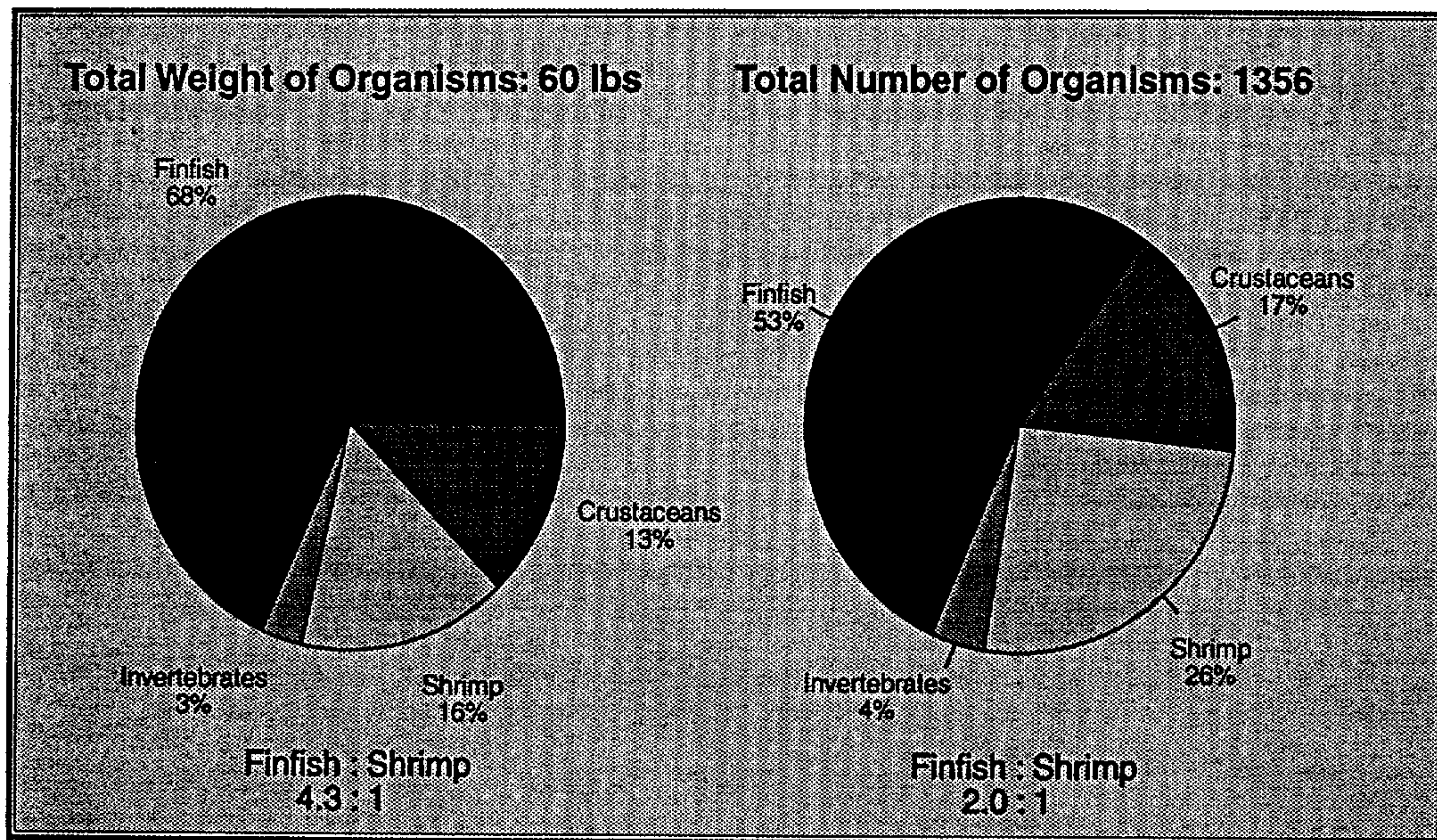
In the Gulf of Mexico, patterns similar to the south Atlantic can be seen in Figure 4, but finfish account for a somewhat larger share of the catch. A trawl pulled for one hour in the Gulf typically nets 1356 organisms weighing roughly 60 pounds. The percentage of the total catch attributable to shrimp is 26 percent, by number, and 16 percent by weight. Compared to south Atlantic trawl catches, finfish occupied a more dominant role in the Gulf- 53 percent by number and 68 percent by weight. Gulf finfish-to-shrimp ratios of 4.3:1 by weight and 2:1 by number reflect these differences.

Catch composition in the Gulf differs from the South Atlantic in notable ways. The top ten species by weight in a typical Gulf trawl make up only 53 percent of the total biomass, compared to 74 percent in the South Atlantic. This is due to the relatively large catches of cannonball jellyfish by shrimpers in the South Atlantic. In descending order, key Gulf species included longspine porgy (15 percent), brown shrimp (9 percent), Atlantic croaker (9 percent), inshore lizardfish (6 percent), pink shrimp (3 percent), gulf butterfish (3 percent), lesser blue crab (2 percent), white shrimp (2 percent), longspine swimming crab (2 percent), and brown rock shrimp (2 percent). The top ten species by number in the same Gulf trawl make up 61 percent of the total and include longspine porgy (19 percent), brown

shrimp (9 percent), Atlantic croaker (6 percent), longspine swimming crab (6 percent), sugar shrimp (5 percent), pink shrimp (4 percent), mantis shrimp (3 percent), lesser blue crab (3 percent), brown rock shrimp (3 percent), and iridescent swimming crab (3 percent).

Finfish-to-shrimp ratios have received considerable attention lately in fisheries circles and the media. Much of this discussion revolves around how these ratios are used and what is, or is not an accurate ratio reflective of present day shrimp fisheries. While ratios once served a useful role in the Gulf in the late 1970s, they are no longer used for estimating shrimp bycatch mortality in lieu of improved methods for accomplishing this task. In general, NMFS recommends against using these ratios whenever possible because they: 1) collapse variations in finfish abundance and variations in shrimp abundance into a single number, 2) vary widely with time and area fished and can be misleading at small time and space scales, and 3) can be further misinterpreted if not evaluated in the context of changing fishing technology (e.g. fishing gear and methods). Nevertheless, they are mentioned in this report because of the level of public interest and confusion over them.

Interestingly, finfish-to-shrimp weight ratios have declined in the Gulf offshore shrimp fishery from values near 10:1 in the 1970's to about 4:1 in 1994. Changing fishing gear, fishing technology, and declining abundances of many species, especially sciaenids (members of the drum family), appear to have contributed to these downward shifting ratios (Nichols, 1994).

The bycatch characterization database offers an excellent vehicle for examining how bycatch varies as a function of time of year, water depth, geographic area and other factors. The relatively large sample size (3,296 tows) will allow managers to view the bycatch issue from many perspectives, a fact that will increase opportunities for identifying potential bycatch reduction strategies. For example, Tables 2 to 4 reveal how shrimp trawl catch composition varies in the South Atlantic and Gulf as a function of different combinations of area, time of year, and water depth. Examination of Table 2 reveals that in the South Atlantic, the highest shrimp catches and lowest finfish bycatch (by number) occurred during the September through December period. Similar inspection of Table 3 reveals that the May through August period in the Gulf yields the highest average catches of shrimp per hour, both in weight and by number, and the lowest finfish-to-shrimp catch ratio.

Table 2:
Average Hourly Shrimp Trawl Catch by Season in the South Atlantic

CATCH	WEIGHT			NUMBER		
	Jan-Apr	May-Aug	Sept-Dec	Jan-Apr	May-Aug	Sept-Dec
FINFISH (%)	50	60	36	62	54	28
SHRIMP (%)	27	24	18	13	32	22
CRUSTACEANS (%)	16	7	7	21	12	10
INVERTEBRATES (%)	6	9	39	4	2	40
TOTAL CATCH	31 lb	51 lb	88 lb	850	1100	1700
FINFISH : SHRIMP	1.9 : 1	2.5 : 1	2 : 1	4.8 : 1	1.7 : 1	1.3 : 1

Table 3:
Average Hourly Shrimp Trawl Catch by Season in the Gulf of Mexico

CATCH	WEIGHT			NUMBER		
	Jan-Apr	May-Aug	Sept-Dec	Jan-Apr	May-Aug	Sept-Dec
FINFISH (%)	64	59	71	47	55	53
SHRIMP (%)	13	18	14	26	27	27
CRUSTACEANS (%)	14	13	11	22	14	17
INVERTEBRATES (%)	9	10	4	5	4	3
TOTAL CATCH	49 lb	71 lb	79 lb	750	1900	1600
FINFISH : SHRIMP	4.9 : 1	3.3 : 1	5.1 : 1	1.8 : 1	2 : 1	2 : 1

Table 4:
Percent Average Hourly
Shrimp Trawl Catch by
Area and Depth

AREA	Finfish (%)	Shrimp (%)	Crusta-ceans (%)	Inverte-brates (%)	Total Catch (No.)	Finfish : Shrimp
SOUTH ATL						
< 60 ft	46	29	11	14	1229	1.6 : 1
≥ 60 ft	56	18	21	5	726	3.1 : 1
FLORIDA						
< 60 ft	37	30	27	6	1207	1.2 : 1
≥ 60 ft	43	29	23	4	802	1.5 : 1
AL-MS						
< 60 ft	47	21	27	4	2480	2.2 : 1
≥ 60 ft	47	22	26	4	3299	2.1 : 1
Louisiana						
< 60 ft	55	36	6	2	2600	1.5 : 1
≥ 60 ft	54	19	21	6	1072	2.8 : 1
TEXAS						
< 60 ft	70	21	7	3	1930	3.3 : 1
≥ 60 ft	56	28	13	3	1346	2 : 1

When catch rates are evaluated as a function of area and water depth, different patterns emerge. The biological productivity of the Mississippi delta region is shown in Table 4. Shallow nearshore waters off Louisiana (less than 60 feet) and the adjacent inshore and offshore waters off Alabama and Mississippi yielded the highest hourly catch rates in total numbers of finfish, shrimp, crustaceans, and invertebrates. Finfish-to-shrimp catch ratios were also lower than for many other areas.

Characterization research also has provided researchers a means to evaluate the efficacy of the GLM for estimating bycatch. For example, researchers estimated red snapper bycatch using five different approaches. Four GLM-based estimates were produced: one was based

on old historical data, a second was based on new data (characterization and BRD testing data), a third was created with new characterization data only, and the fourth was based on all observer data, combined. For comparison, a separate estimate was made for each of the last 2 years expanding the new characterization data without the GLM procedure. Surprisingly, as Figure 5 illustrates, all five estimates were very similar and thus have the same implications as inputs to the stock assessment process. Any differences between estimates resulting from the use of historical (1972-1982) versus new data would have been caused by four factors: sampling variation, strategic changes in fishing methods, changes in gear efficiency, and the effect of TED use. Clearly, for red snapper, any changes in bycatch during this period relative to one factor have been balanced by changes in other areas. Similar analyses for other important species will be conducted.

Figure 5:
Comparison of Five Different Methods for Estimating Red Snapper Bycatch in the Gulf of Mexico
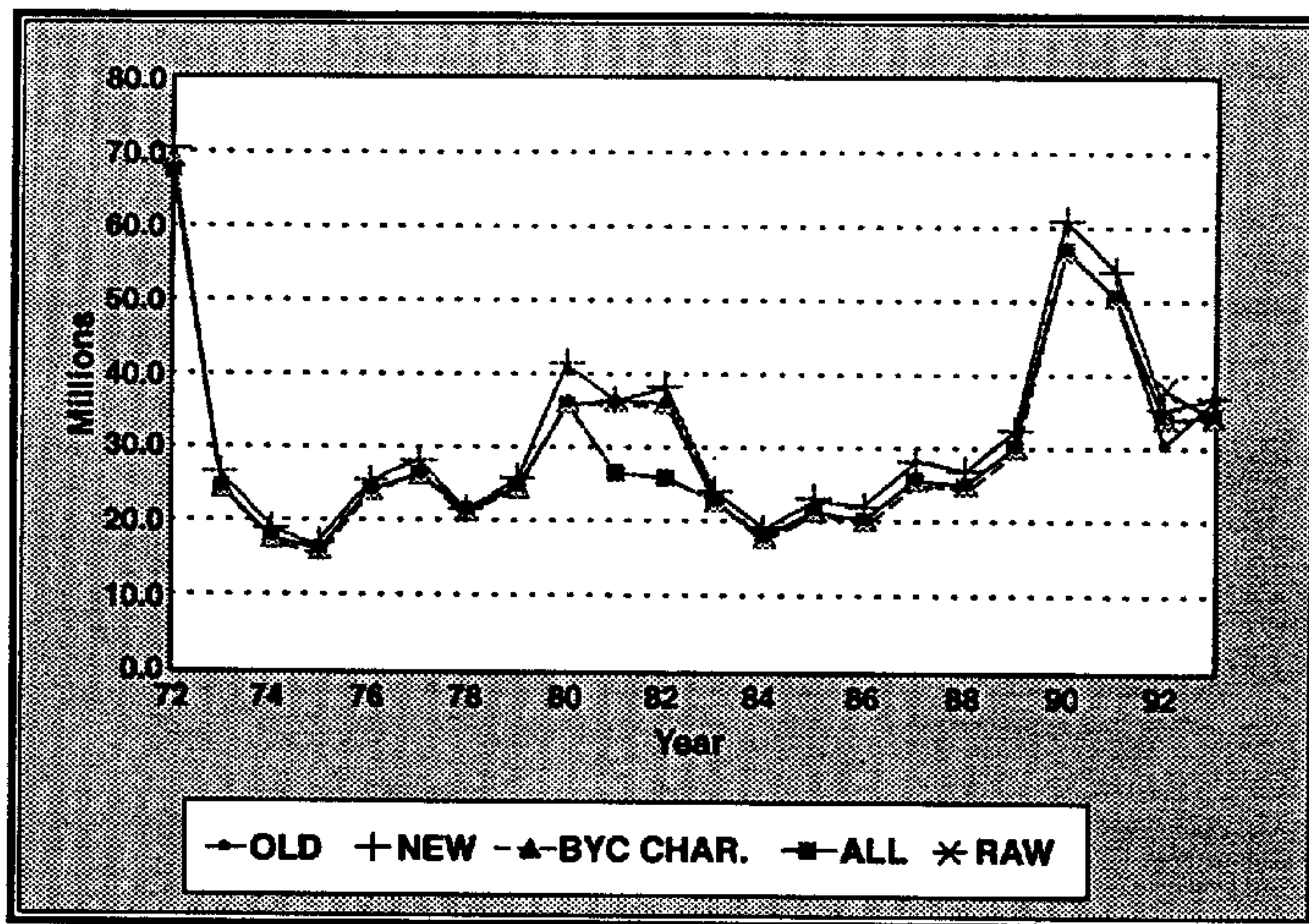
Several important points can be drawn from this analysis. First, onboard observer-based bycatch characterization studies will be needed periodically to document changes in bycatch over time, especially if major changes in the shrimp fishery occur. Second, based on preliminary comparative analyses of bycatch estimates generated by onboard sampling and GLM-based approaches, it appears GLM-based estimation procedures offer a cost-effective approach for updating bycatch estimates during periods of little fishery change. They may also be used to fill time and area sampling cells where observer coverage is lacking. Third, it appears that historical and new bycatch data may be combined to form an even more useful bycatch data time series. Lastly, additional analyses may be needed to understand differences in species specific bycatch estimates generated by these different methods. Because of the universal importance of bycatch estimates, the involvement of NMFS and non-NMFS researchers will be essential in validating these findings.

Program Objective II

Improve Assessments of Significantly Affected Federally Managed Stocks

Program Needs

While the immediate objective of characterization research is to determine the magnitude and species composition of bycatch, a major need exists to generate additional information to help managers assess the status of affected stocks. To accomplish this, species-level CPUE and length information needs to be collected on shrimp trawls throughout the shrimping season. Age and sex information would likewise be helpful. This information is missing or inadequate for many species, a fact that frustrates managers in their efforts to assess the status of marine fish stocks.

Research Actions:

(1) Collect life history information during characterization and BRD testing research using standard collection protocols.

(2) Enter and maintain data in a common database to support stock assessments for federally-managed species and to assess the vulnerability of different species and age classes to trawl gear.

Sampling Sequence 1: Cod end of trawl brought aboard.

Sampling Sequence 2: Catch is dumped on rear deck.

Sampling Sequence 3: Observer takes and sorts sample from trawl.
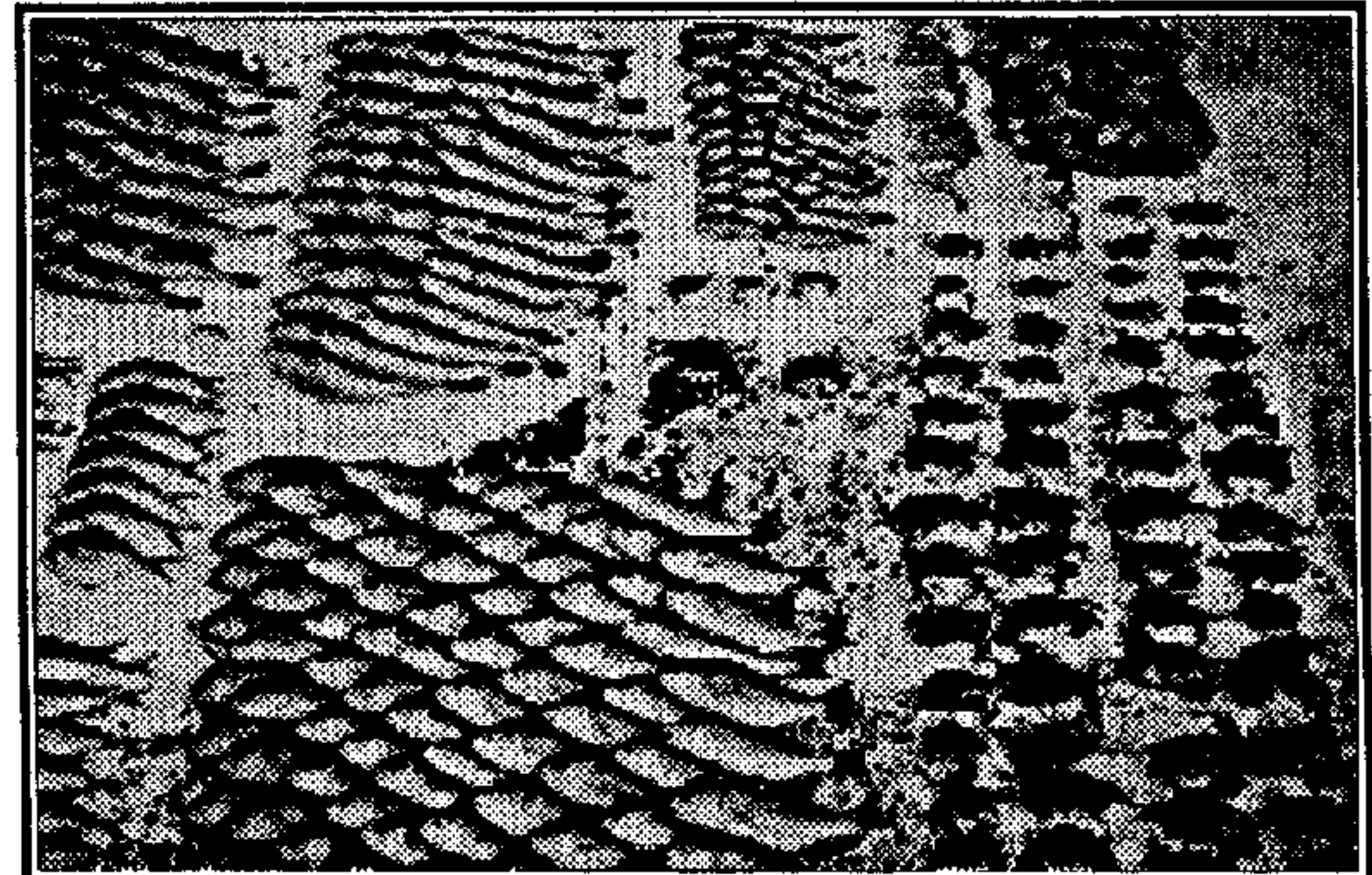
Sampling Sequence 4: Species are identified, counted, and measured. (Not necessarily an average catch)

Significant Accomplishments

Collection of Essential Stock Assessment Data

Accomplishments in this research program area have been significant and inextricably tied to bycatch characterization efforts. Over the last 28 months, NMFS and non-NMFS observers aboard commercial shrimp trawlers have amassed a large bycatch characterization data base consisting of CPUE and related biological information. Standard sampling protocols, which were used by all observers, involved taking a 26-pound sample (or a sub-sample, when warranted) from a randomly selected net for every hour trawled by the vessel (NMFS, 1992a). After the total catch in the selected net was weighed and the catch was thoroughly mixed, the 26-pound random sample was extracted and all specimens in the sample were identified to species. For each species group represented, the number of individuals was recorded along with their total weight, and length measurements were made for up to 30 randomly selected individuals.

This sampling procedure has produced a large biological database that will be used to enhance stock assessments for many key federally managed species in the Southeast Region. In the South Atlantic area, 656 trawl hours were sampled, resulting in the characterization of 17,059 pounds of sampled trawl catch representing over 150 species of finfish, and crustaceans, and other invertebrates. In the Gulf, 5,441 trawl hours were sampled resulting in the characterization of 141,453 pounds of sampled catch representing over 450 species. In both areas, some species were represented by as few as one individual while others numbered in the hundreds of thousands. All resulting data have been processed, edited, checked, and entered into the centralized database at the NMFS Galveston Laboratory and are being analyzed and used in fishery management decisions.

Application of Data to Improve Stock Assesments

The bycatch characterization database represents a substantial and valuable tool in improving the ability to assess the status of various marine fish stocks, especially for species that are numerically well represented in the database. This information is being used in several important ways to improve stock assessments. First, CPUE and length frequency information collected over broad areas throughout the year is providing useful seasonal and areal indices of abundance for many species.

Table 5: Preliminary Estimates of Total Bycatch for Selected Species in the Gulf Offshore Shrimp Fishery - 1993

SPECIES BYCATCH (millions of Fish)	
Atlantic Croaker	13,000
Longspine Porgy	4,400
Spot	400
Red Snapper	35
Spanish Mackerel	5
King Mackerel	0.725
Total Weight of Finfish Bycatch (all species including 6 million pounds of sharks)	600 Million lbs.

Second, estimates of total bycatch for species of concern can be produced from the database by multiplying CPUE data for that species in a given cell (e.g., area, depth zone, and season) by the total estimated shrimp effort for that cell and summing cell catches to get a total catch. Table 5 displays some preliminary estimates of total bycatch for several species to demonstrate how the magnitude of bycatch can vary significantly from one species to another. While knowing the total shrimp trawl bycatch for a given species is important, that estimate becomes meaningful only when considered in the context of the species' overall stock size, its bycatch by age class, and the

Figure 6:
Size Frequency of Red Snapper Sampled During Study.

Number Observations = 5700
Median = 105.0 mm
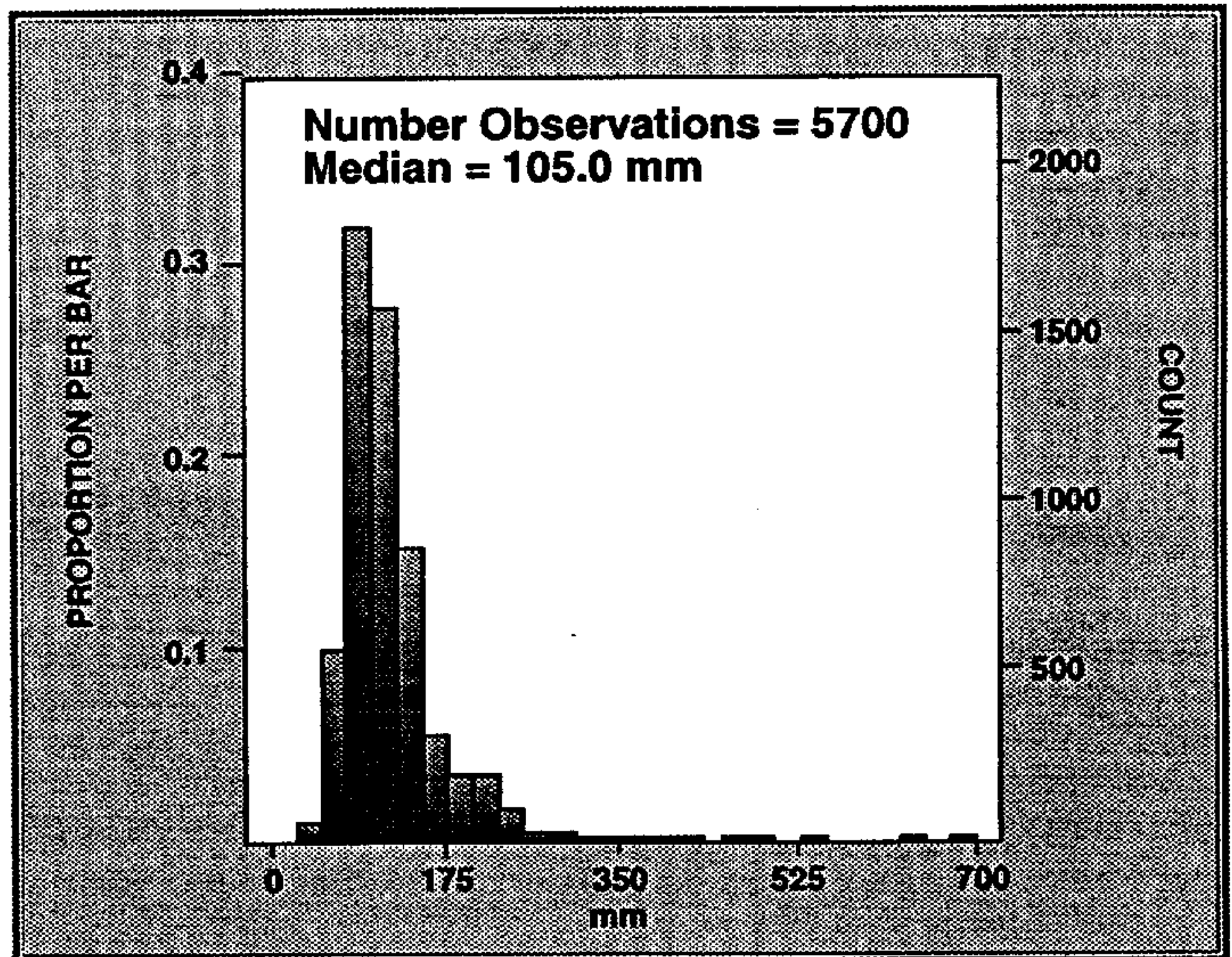
Figure 7:
Red Snapper Mortality Estimates Average 1984-1993

Annual Instantaneous Fishing Mortality Rate

Age in Years

SHRIMP BYC   COMM HOOK & LINE

BOTTOM LONGLINE   RECREATIONAL

Source (Goodyear, 1994)
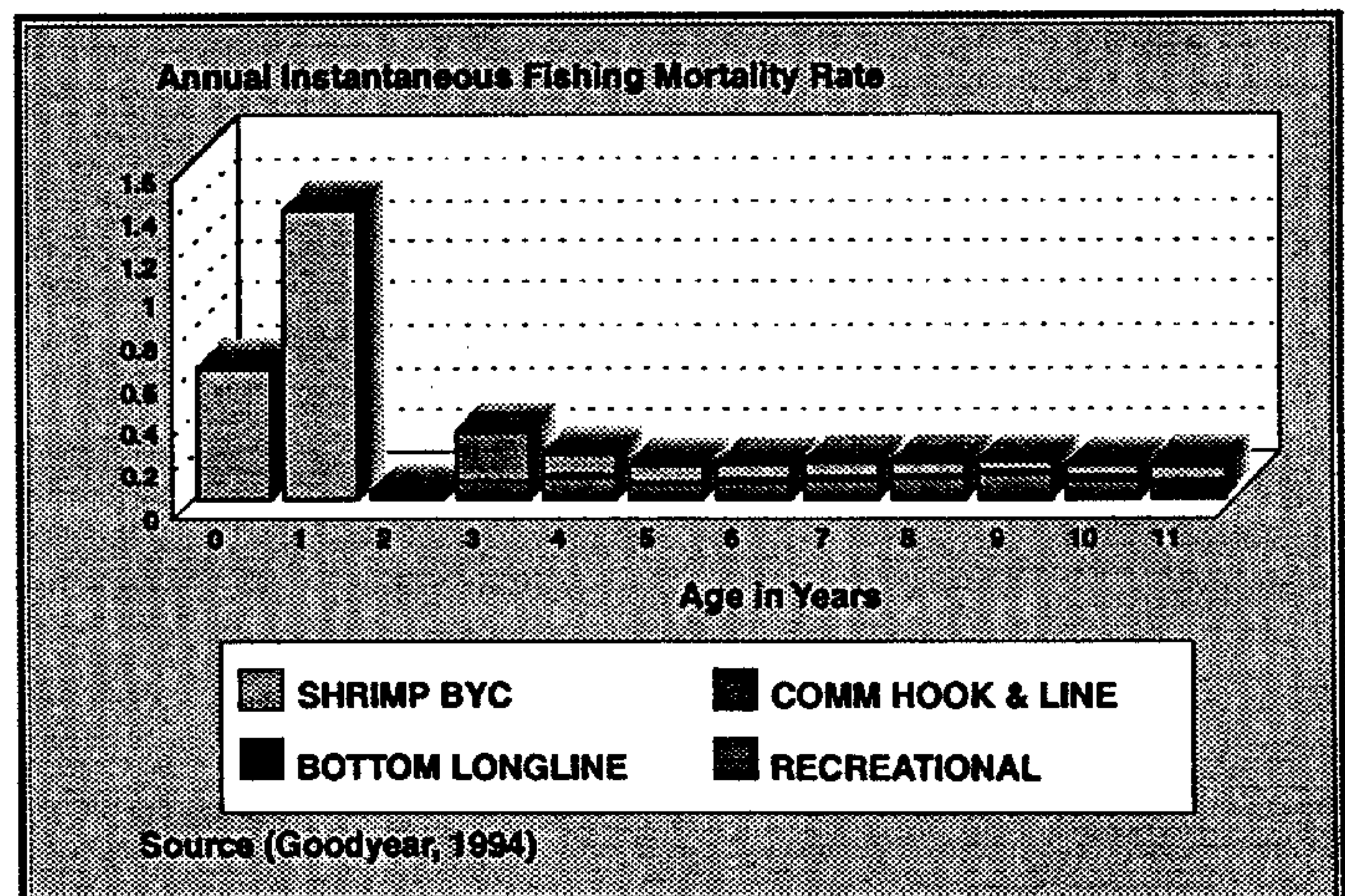
magnitude of shrimp bycatch relative to other sources of directed or non-directed fishing mortality. Taken together, this information enables managers to more completely assess the impact of bycatch on the status of a given stock. Estimates of total bycatch for key federally managed species will be developed and further refined as program data collection, entry, and analysis tasks are completed.

Examination of red snapper data provides an example of the utility of this database for improving stock assessments. Bycatch characterization data confirms that total shrimp bycatch induced mortality for red snapper in the Gulf of Mexico was approximately 35 million fish in 1993. As mentioned before, this number is much more meaningful when managers know the age distribution of red snapper taken as bycatch. Analysis of length measurements taken by observers shows a high bycatch of small young red snapper. Plotting the size distribution of the 5,700 red snapper that were removed from sample trawls and measured (see Figure 6) reveals a median size of 105 millimeters, or roughly 4 inches. Four-inch red snapper are considered age 0 but they shift from age 0 to age 1 as they move from 4 to 6 inches in length.

RED SNAPPER
Lutjanus campechanus

Description: color pinkish red over entire body, whitish below; long triangular snout; anal fin sharply pointed; no dark lateral spot.

Where found: Offshore on the continental shelf, more plentiful off the Florida panhandle and the western Gulf.

Size: to 20 pounds.

Remarks: juveniles occur over sandy or mud bottoms and often taken in shrimp trawls; adults may live more than 20 years, and attain 35 pounds or more; sexual maturity attained at age 2; spawns June to October; feeds on crustaceans and fish.

Reprinted courtesy of Florida Dept. of Environmental Protection (OFMAS). Artist: Diane Rome Peebles
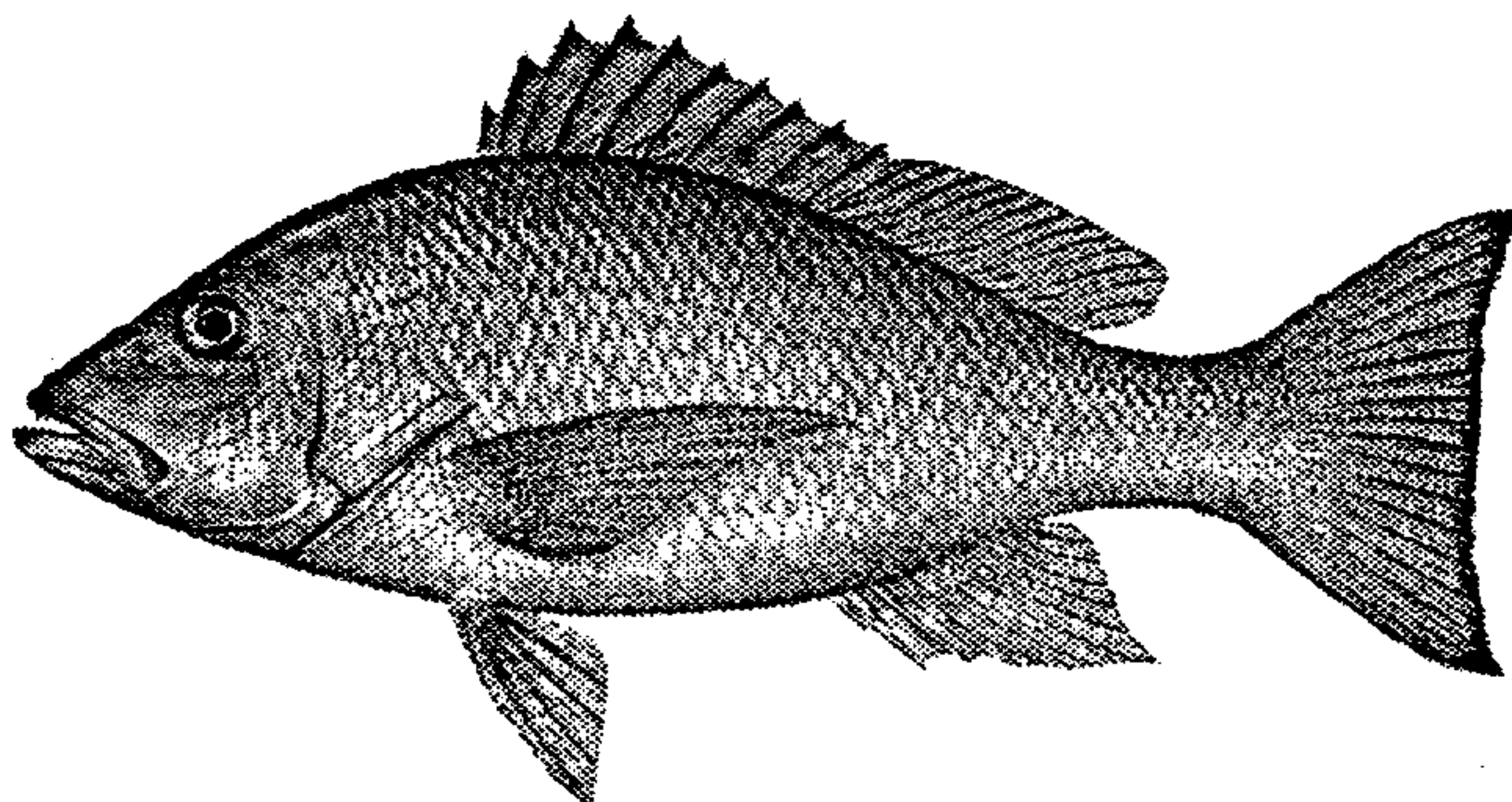
Knowing the annual fishing mortality rates by age for a given species and the source(s) of that mortality enhances the quality of stock assessments. It also helps managers develop appropriate measures to keep fishing mortality within acceptable limits. For example, researchers have assembled Figure 7, which shows the annual instantaneous fishing mortality rates for red snapper age 1 to 11. It also shows the relative importance of each major source of fishing mortality. Figure 7 shows that shrimp trawl bycatch is the principal source of fishing mortality (effectively 100 percent) for small age 0 and age 1 red snapper. This information has already been used to update the Gulf red snapper stock assessment and is being considered by the Gulf of Mexico Fishery Management Council in deliberations regarding possible amendments to the reef fish and shrimp fishery management plans.

Bycatch characterization information for other federally managed species like king mackerel, Spanish mackerel, and sharks, is also being processed, analyzed, and will be used, as appropriate, to update stock assessments. Management plan adjustments, if any, relative to these affected species, will be based in part on these improved assessments.

Program Objective III

Develop and Evaluate Bycatch Reduction Devices (BRDs)

Program Needs

Trawl gear modification is probably the most economical and least disruptive approach to minimizing finfish bycatch in shrimp fisheries. While some TEDs measurably reduce bycatch, their actual performance needs to be adequately documented. Further, researchers and fishermen have suggested additional trawl modification ideas that need to be carefully evaluated to determine their bycatch reduction and shrimp retention performance. Consequently, a process is needed to rapidly develop and evaluate BRDs or alternative shrimp fishing gear, and to transfer this technology to the shrimp fleet.

Research Actions:

(1) Develop a suitable BRD development and testing protocol that is both sufficiently rigorous from a scientific perspective and acceptable to the shrimp industry.

(2) Organize and use a gear development panel to cooperatively identify and evaluate BRD concepts and designs.

(3) Evaluate BRDs and alternative gear using standardized testing criteria, procedures, and data collection protocols.

Significant Accomplishments

Getting Organized

Owing to extensive involvement and cooperation among the shrimp industry, the Foundation, NMFS, states, Sea Grant, and university researchers, two bycatch reduction devices have been developed which appear to meet research program performance criteria of reducing bycatch-induced red snapper mortality by 50 percent with minimal or no shrimp loss. Testing of these two BRDs aboard commercial shrimp vessels is continuing to confirm these findings and make additional gear refinements.

In order to make such significant strides in the relatively short time frame of 2 to 3 years, program cooperators have had to overcome several substantial challenges. First, a procedure for developing and testing BRDs had to be devised that was scientifically rigorous and acceptable to the shrimp industry. In large measure, the substantial expertise and experience gained in developing Turtle Excluder Devices (TEDs) in the late 1970s and early 1980s expedited completion of this task. At the outset of BRD development in 1990, NMFS researchers recognized that TEDs would likely be required in all waters year-round by 1992. Therefore, step one in this process had to involve the careful evaluation of certified TEDs to establish their bycatch reduction performance. A second step was needed to carry the process further to develop and test additional trawl modifications that could be used in combination with TEDs to further enhance their finfish exclusion performance. New certified TEDS could also result from this process.

With this two-step approach in mind, a TED evaluation procedure and four-phase BRD-testing protocol were developed and recommended in the "Bycatch Research Requirements Document" published by NMFS in November 1991. Based on recommendations of the Foundation's Bycatch Steering Committee, these procedures were reviewed and approved by an expert panel assembled by the Steering Committee. The approved development and testing protocols have been the cornerstone of this effort and are described in detail in Appendix III.

Second, with an approved BRD testing protocol in hand, a formal mechanism was needed to solicit BRD ideas and designs from industry and others and to select promising ideas for formal evaluation. Again, based on advice from the Foundation's Bycatch Steering Committee, an eight-member Gear Review Panel was established representing the shrimp industry and key state and NMFS gear technology specialists to perform these important solicitation and screening functions (see Appendix IV for membership list).

Having addressed these two challenges, cooperators turned to the task of developing BRDs capable of substantially reducing shrimp trawl bycatch-induced mortality on key federally managed species. Red snapper bycatch reduction has been the principal focus of this effort for two reasons. First, the Gulf of Mexico Fishery Management Council has been concerned that Gulf red snapper stocks are overfished and will not recover from this overfished status by the 2009 target date unless shrimp bycatch-related mortality is reduced by 50 percent beginning in 1995 or 1996. Second, to achieve this bycatch reduction goal, BRDs must be designed that can eliminate small red snapper from trawl nets, a difficult feat owing to the fact that shrimp are nearly the same size, and that juvenile red snapper are strongly attracted to objects, including shrimp nets. Once inside a shrimp trawl net, especially the cod end, young red snapper must be actively stimulated to exit. Physical sorting methods alone would likely not be effective without high shrimp loss.

TED Evaluations

There are three basic TED types certified for use by the shrimp industry under the Endangered Species Act (ESA) regulations; hooped-hard TEDs, single-grid hard TEDs, and soft TEDs. Evaluation of the finfish reduction potential for hooped hard TEDs was conducted by Watson et al, in 1986 and for single grid TEDs by Renaud et al, in 1990. Evaluation of the finfish reduction potential of certified soft TED designs is being conducted by researchers associated with the University of Georgia Marine Extension Service and the Texas A&M Sea Grant Program. Hooped-hard TEDs with finfish exclusion modifications demonstrated total finfish reduction rates of 53-70 percent with shrimp retention rates of 95-99 percent (Watson et al, 1986). The hooped-TED designs are not popular with shrimp fishermen and are used by less than 1 percent of the fleet. The most common TED type currently in use by the shrimp fleet is single-grid hard TEDs. Total finfish reduction rates for these designs was 3-9 percent with shrimp retention rates of 86-100 percent (Renaud et al, 1990).

Preliminary results of finfish reduction testing for soft TED designs indicate significant finfish reduction potential, particularly for the 5-inch Andrews soft TED. Use of the 5-inch Andrews soft TED by shrimpers increased in 1994 and there is a current study on its finfish reduction potential being conducted by Texas A&M Sea Grant researchers.

Clearly, TEDs reduce the bycatch of various finfish species to differing degrees. To the credit of the shrimp industry, the widespread use of TEDs is contributing to bycatch reduction. This contribution is reflected in bycatch estimates being generated through this program. The significance of this contribution will vary over time as a function of fleet use rates for specific TEDs, changes in shrimping gear and methods, and fluctuations in overall shrimping effort and finfish abundance. Widespread dissemination of TED testing results and increased use of TEDs exhibiting higher bycatch reduction performance will contribute further to bycatch reduction.

BRD Design and Evaluation

Figure 8 summarizes progress made to date in designing and evaluating BRDs (Watson et al, 1993; Watson, 1994a and 1994b; Workman et al, 1994). Eighty-two different BRD designs have been prototype tested to determine potential feasibility of the design as reflected by preliminary catch performance and the behavioral response of fish to the gear. Prototype testing has been performed chiefly by NMFS Harvesting Systems Division personnel by towing BRDs behind research vessels in relatively shallow and clear water and documenting performance utilizing SCUBA, acoustic instrumentation, hand-held and remotely-operated video cameras, and other gear. If the feasibility of a design was affirmed, the prototype BRD advanced to the next testing phase.

Figure 8: BRD Testing Program Results

82 BRD Designs Prototype Tested

⬇

24 Designs Proof-of-Concept Tested (Only 4 achieved > 50% finfish exclusion with < 3% shrimp loss

⬇

3 BRDs In Operational Testing
• **large mesh funnel**
• **extended funnel**
• **fish eye**
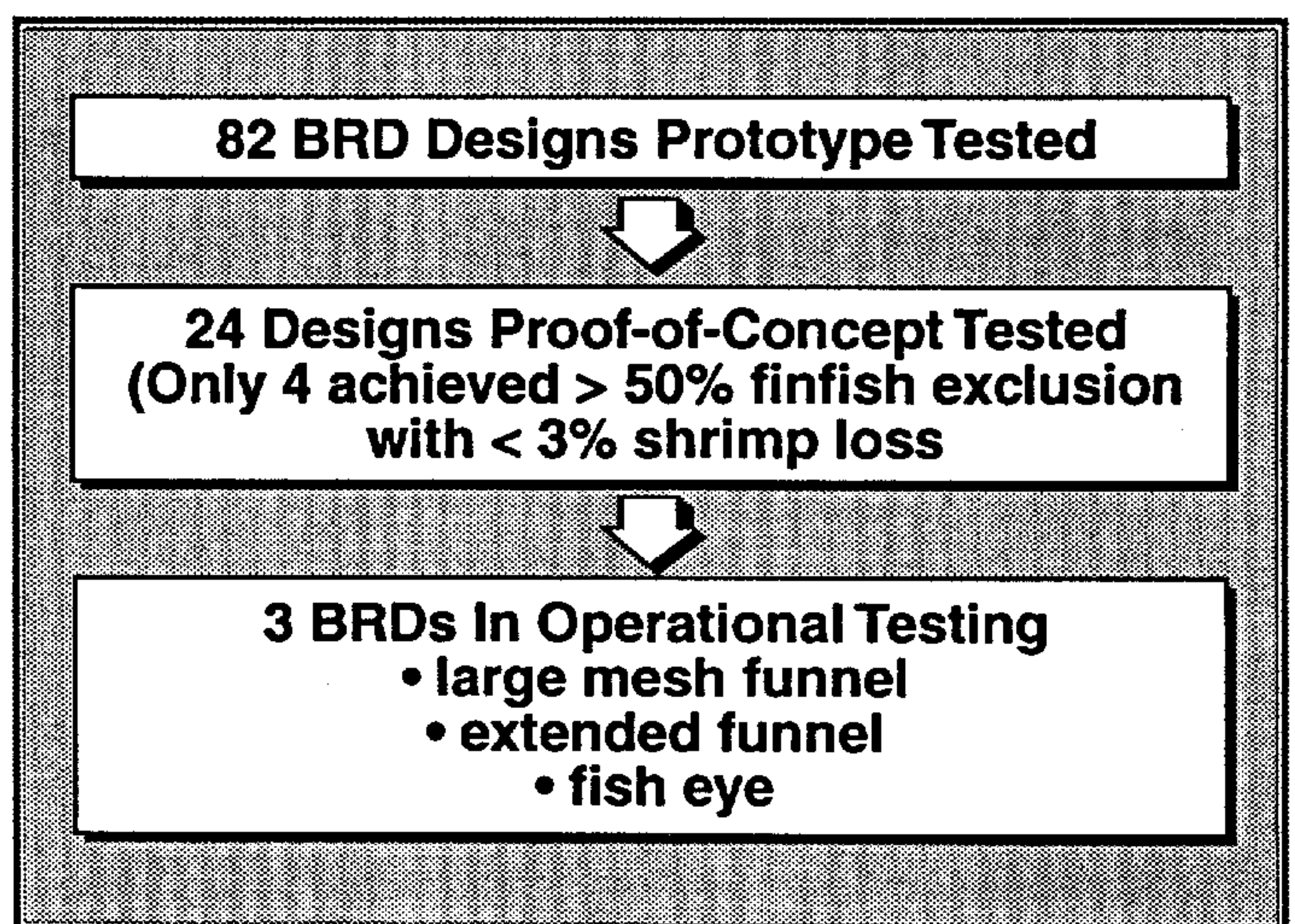
Of 82 prototype-tested BRDs, only 24 advanced to proof-of-concept testing. In this phase, prototype devices were trawled behind research or contracted commercial shrimp vessels to determine their finfish exclusion rates for key finfish species, shrimp retention rates, simplicity of use, and safety. In this process, prototypes were tested as a BRD/TED combination against a standard net equipped with the same TED. To pass this testing phase, the BRD/TED combination had to reduce bycatch by at least 50 percent with less than 3 percent shrimp loss. Only four BRD designs met these criteria.

Operational testing was conducted for three of the four BRD designs that passed the proof-of-concept testing phase: the large mesh funnel, the extended funnel, and fish eye. The fourth design, a NMFS-modified TED design, was approved by the Gear Review Panel for operational testing, but was not pursued because it was considered impractical under commercial conditions. During operational testing, BRD/TED combination gears were tested against a TED net on cooperating commercial shrimp vessels under normal shrimping conditions. Trained observers working in the bycatch characterization research effort were deployed on these vessels to document finfish exclusion and shrimp retention rates. Notably, during operational testing trips, observers also obtained bycatch characterization samples from the control nets using established protocols, and resulting data were entered into the database.

Operational testing results on the extended funnel and fish eye BRDs are being analyzed by NMFS researchers and will be available this spring. Results will include exclusion rates for a variety of key species. The large-mesh funnel has been operationally tested by state and Sea Grant researchers along the south Atlantic coast. Results are likewise being analyzed and will be available this spring.

Table 6:
Operational Testing Performance of the Fish Eye and Extended Funnel BRDs

BRD TYPE	OVERALL FISH REDUCTION	RED SNAPPER REDUCTION	SHRIMP RETENTION
Fish eye	33% n=326	27% n=176	99% n=339
Extended Funnel	23% n=161	26% n=134	103% n=161
n= number of tows			

Based on operational testing results, two BRDs have advanced to industry evaluation, the final stage of BRD testing. These two BRD designs, the extended funnel and fish eye, are being deployed from cooperating commercial shrimp vessels for further evaluation by captains. Total finfish and shrimp catches for the BRD and standard TED nets will be recorded in log books. Observers are being placed on a subset of these vessels to collect species-specific bycatch data.

The fish eye (Figure 9), and the extended funnel (Figure 10), have demonstrated very promising red snapper exclusion performance. As reflected in Table 6, both nets have exhibited good overall finfish reduction, excluding 26 percent of juvenile red snapper, overall. By analyzing the exclusion rates for specific size/age groups, NMFS stock assessment biologists have determined that both BRD designs are capable of reducing overall bycatch-induced red snapper mortality by 40-60 percent, the bycatch program target. Further, as Table 6 indicates, shrimp retention by these two BRDs has been excellent.

Figure 9:
Fish Eye BRD

Side
View

- The fish eye is an industry-developed design which consists of a football or round-shaped frame inserted into a trawl extension or cod end to provide an opening for fish to escape.

- Dye flow tests indicate the water flow entering the opening of the device was reduced, providing a stimulus for fish escapement.

- The fish eye was tested in three different positions; in the top of the cod end, in the bottom of the extension, and on the sides of the extension behind a grid-style TED.

Prototype testing of a
Fish Eye BRD
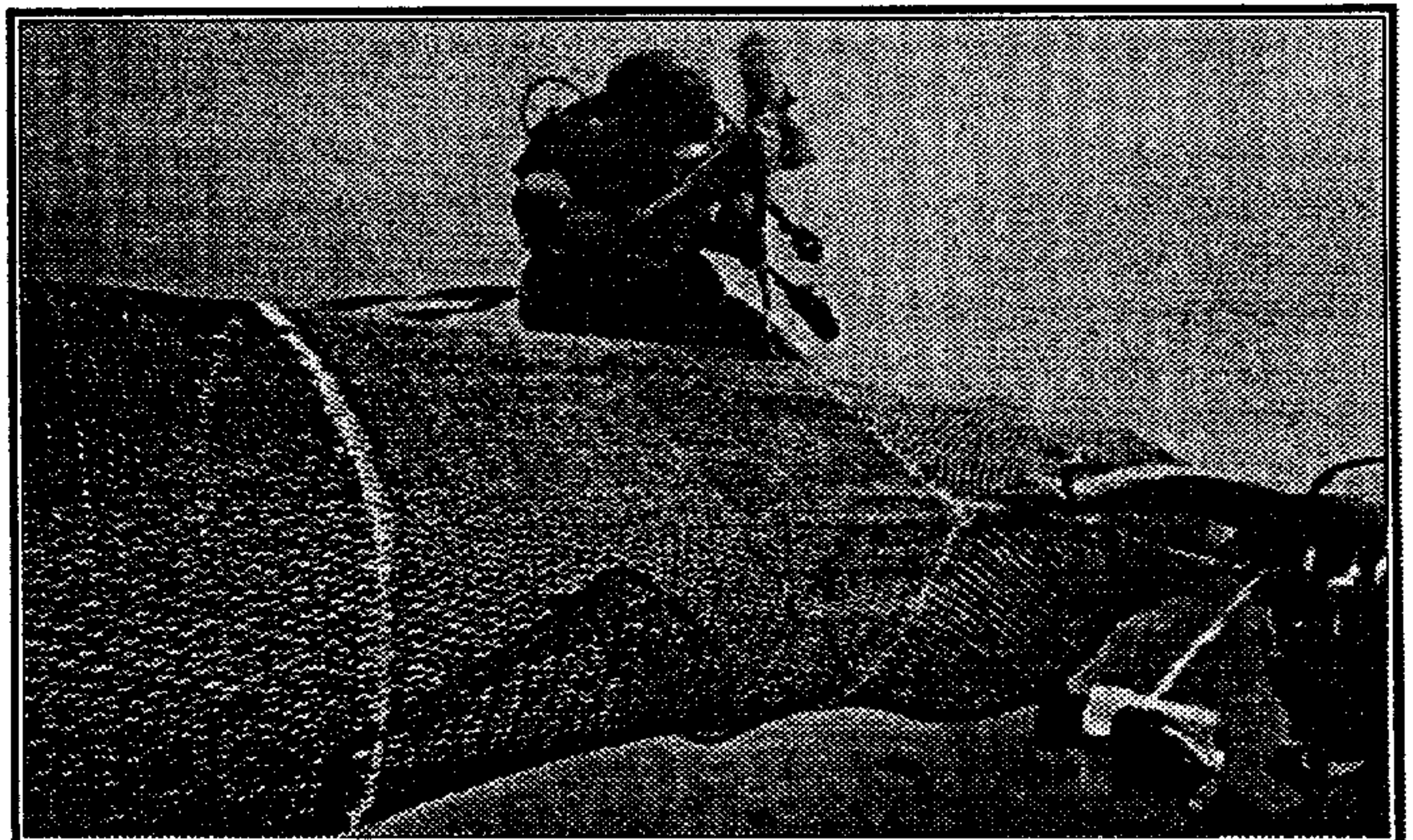
Figure 10:
Extended Funnel BRD

- This design consists of a small-mesh webbing funnel surrounded by a large-mesh escape section held open by one plastic-coated cable hoop.

- One side of the funnel is extended to form a lead panel that creates an area of reduced water flow on the backside of the funnel. It is placed behind the hard-grid TED between the TED and the cod end.
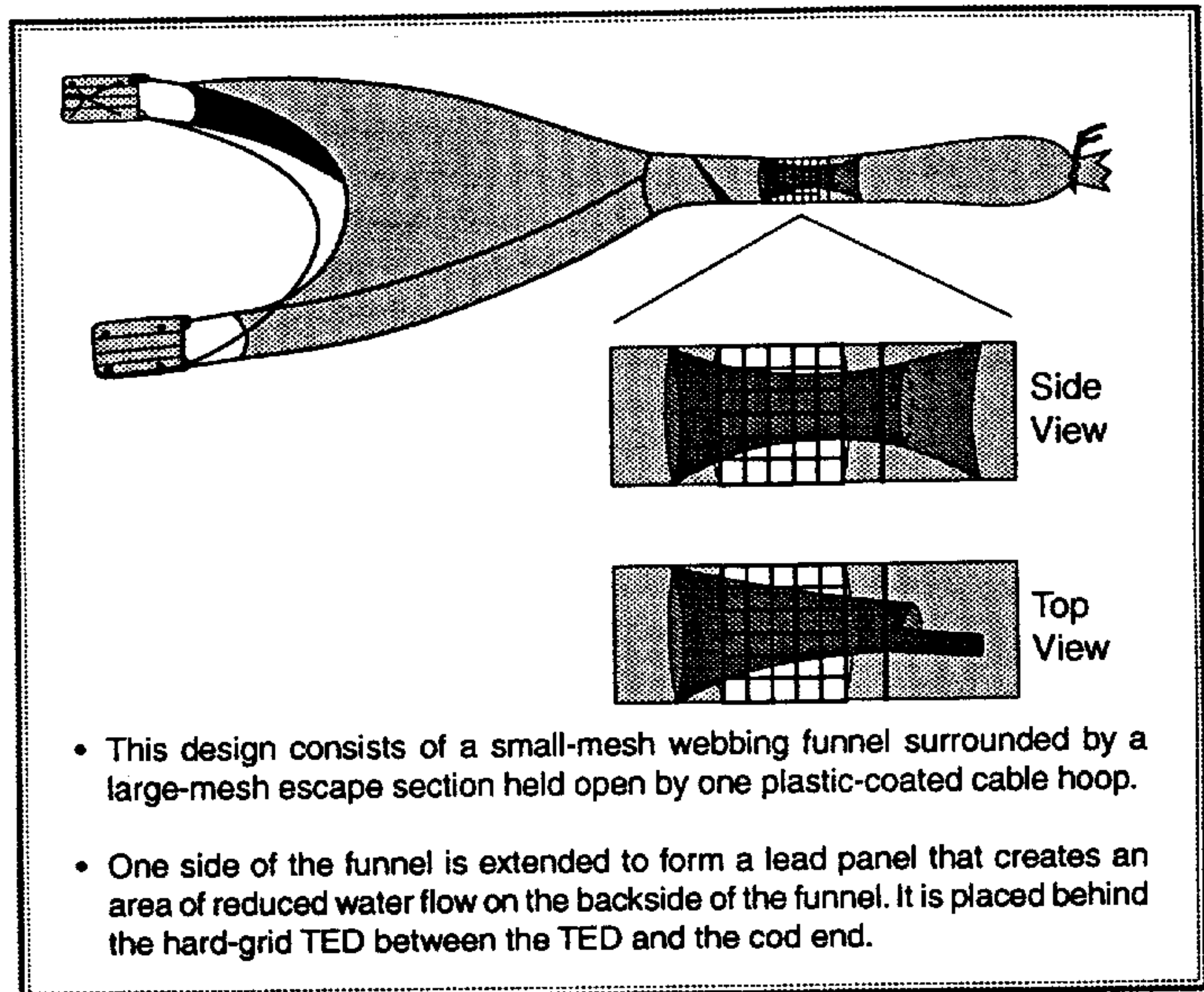
Prototype testing of an
Extended Funnel BRD
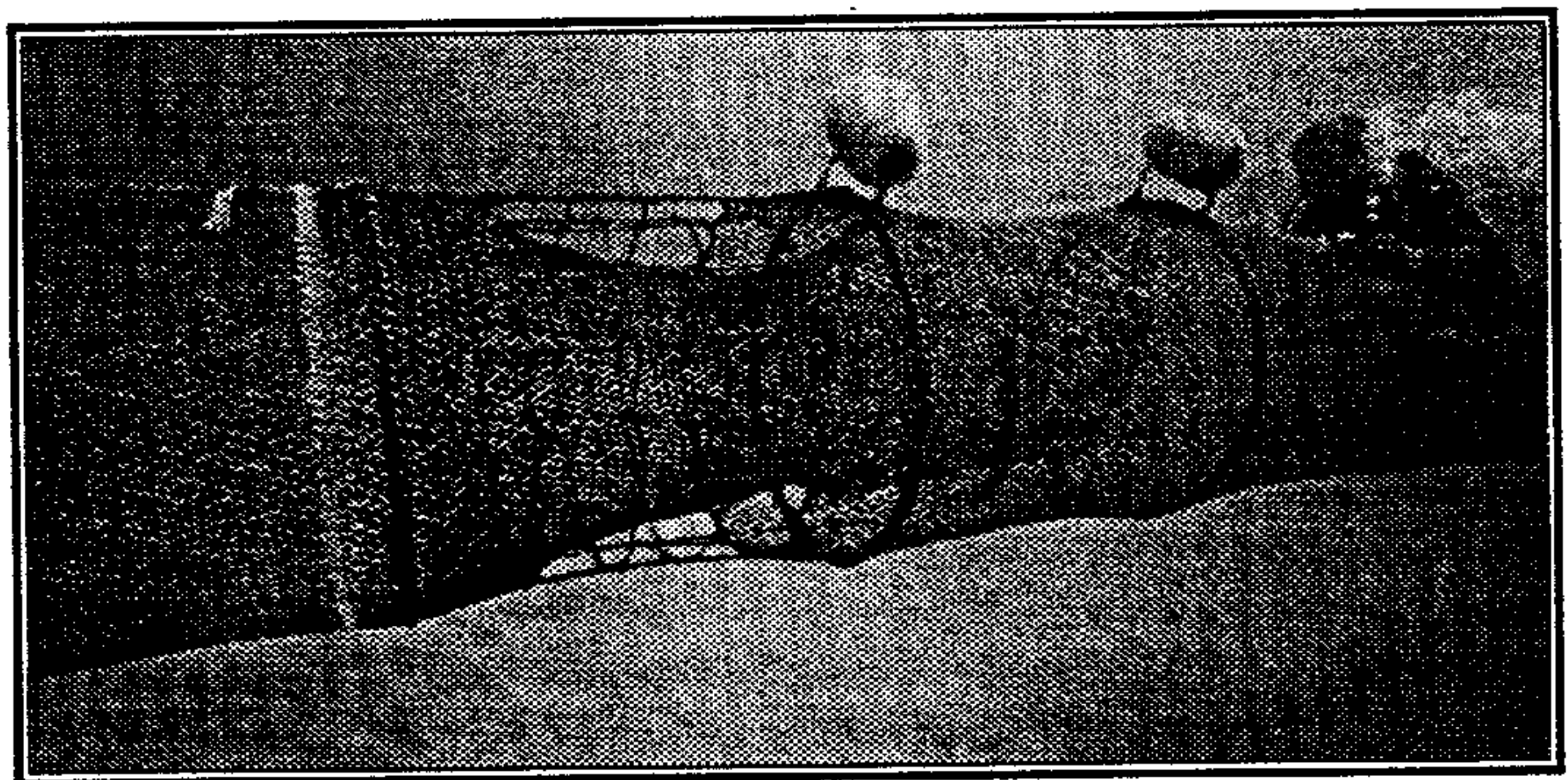
In 1995, industry testing of the fish eye and extended funnel will continue, as will the search for additional BRD designs capable of meeting established program objectives. A BRD certification procedure has been drafted and will be presented to the Gear Review Panel for review and refinement. At some point in 1995, this certification procedure will be formally reviewed, adopted, and implemented so that a list of certified BRDs can be developed and made available to state and federal managers and the southeast shrimp industry.

Program Objective IV

Identify and Evaluate Non-Gear and Tactical Bycatch Reduction Options

Program Needs

Congress mandated consideration of all possible bycatch management measures, including both gear and non-gear-based approaches. Potential non-gear approaches include season or area closures, time-of-day closures, explicit fishing effort limits, and onboard bycatch handling procedures. Identification of possible approaches requires access to improved bycatch data that can be overlaid on the spatial and temporal dimensions of fleet operations during the fishing year. Analysis of the data can then be used to identify times, areas, or depths when bycatch of key species is particularly low or high. Potential bycatch reduction strategies identified through this process can then be subjected to rigorous evaluation. Similarly, the potential for reducing bycatch mortality through changes in onboard bycatch handling procedures needs further investigation.

Research Actions

(1) Assemble and analyze bycatch data to identify catch patterns that suggest potential non-gear management approaches for key species.

(2) Investigate the potential benefits of alternative onboard handling and sorting procedures for reducing bycatch mortality.

Significant Accomplishments

Now that initial bycatch characterization research has been substantially completed and resulting data have been compiled into a working database, efforts to identify potentially viable non-gear bycatch reduction strategies will begin in earnest. Momentum to begin this task was imparted by decisions of the Gulf of Mexico Fishery Management Council in September 1994, and the South Atlantic Council in October 1994, to begin developing bycatch-related amendments to their respective shrimp fishery management plans. Council staffs are working with NMFS and state researchers to identify and evaluate the full range of potential bycatch reduction approaches. Over the next 6 to 12 months, this will involve in-depth analysis of characterization data to identify times or areas where the bycatch of key species of concern (e.g., king mackerel, Spanish mackerel, red snapper, weakfish, and red drum) is particularly high. This analysis may lead to consideration of specific time or area closures, either in lieu of, or in combination with, gear-based options like BRDs. Further, several studies have been initiated with MARFIN and Saltonstall-Kennedy funds to explore the use of onboard handling and sorting techniques to reduce bycatch mortality.

Program Objective V

Evaluate the Biological, Sociological, and Economic Impacts of Bycatch Management Options

Program Needs

Bycatch management has the potential of generating significant biological, social, and economic impacts in the Southeast. Estimating the nature and magnitude of impacts generated by potential bycatch management options requires improvements in the amount and quality of social, cultural, catch, effort, and shrimping cost/returns information. It also requires the availability of appropriate bioeconomic and ecosystem models for use in evaluating management options.

Research Actions:

(1) Collect priority social and cultural information on shrimp fishermen.

(2) Update and improve shrimp catch/effort estimates and cost/returns information.

(3) Develop, tune, and use bio-economic models for evaluating bycatch management options.

(4) Develop, refine, and apply ecosystem models to estimate likely ecosystem changes generated by bycatch management options.

Significant Accomplishments:

Four analytical approaches are available to help determine the potential effectiveness of bycatch management options. The first involves the use of stock assessments to determine how specific stock conditions might improve in response to management measures that reduce bycatch-induced fishing mortality rates. The second approach involves the use of bioeconomic models which can enable managers to estimate the biological and economic impacts of proposed management measures. The third approach involves the application of social impact assessment techniques to estimate the social and cultural impacts of proposed management measures at the individual and community levels. The fourth approach involves the use of ecosystem models to evaluate potential benefits or impacts of altering existing bycatch discard rates and associated finfish mortality levels. Previously described bycatch characterization research is providing data needed to improve stock assessments for affected species. Progress made under this research objective constitutes a significant step in improving the use of bioeconomic models, social impact assessment techniques, and ecosystem models for evaluating potential bycatch management options.

Collection of Critical Social and Economic Data

At the most basic level, limited but significant progress is being made in collecting critical social and economic data on the shrimp fishery. Social science researchers at the University of South Alabama have nearly completed a 2-year study designed to generate Gulf-wide baseline data characterizing the economic, social, and psychological well-being of shrimp fishermen (Thomas, 1994).

Phase one in this study collected data on shrimpers from Bayou La Batre, Alabama during 1993-1994 and compared them with similar data collected in the Bayou in 1987 (Thomas, 1987). From this effort, researchers have been able to characterize changes that have occurred in the demographics of shrimpers in this area, their feelings of "well-being" (e.g., stress levels), their preferences regarding bycatch management options, and the likely impact of bycatch regulations on their continued participation in the fishery.

The research provides interesting insights about shrimpers in the Bayou La Batre area. Compared with conditions in 1987, captains in 1994 tended to be older and more experienced, had experienced significant income losses, and felt that the value of their boats and gear had declined. In 1994, more vessel owners captained their own boats and employed fewer crew due to financial hardships and had increasingly negative perceptions of their present lives as commercial fishermen, even though they still derive great intrinsic rewards from their trade. Interestingly, job satisfaction levels did not changed significantly between 1987 and 1994. Looking to the future, there was considerable concern about the possible effects of new regulations aimed at reducing bycatch. Some believed these regulations could result in higher levels of attrition (Thomas, 1994).

Due to growing interest in this type of human-dimension research, the study was expanded to collect similar baseline information on shrimpers throughout the Gulf of Mexico. Researchers at the University of South Carolina are likewise working to characterize some of the social and economic dimensions of the bycatch issue in South Carolina ports, especially concerning the use of bycatch by special consumer groups.

Major U.S. Shrimp Ports in the Gulf and South Atlantic
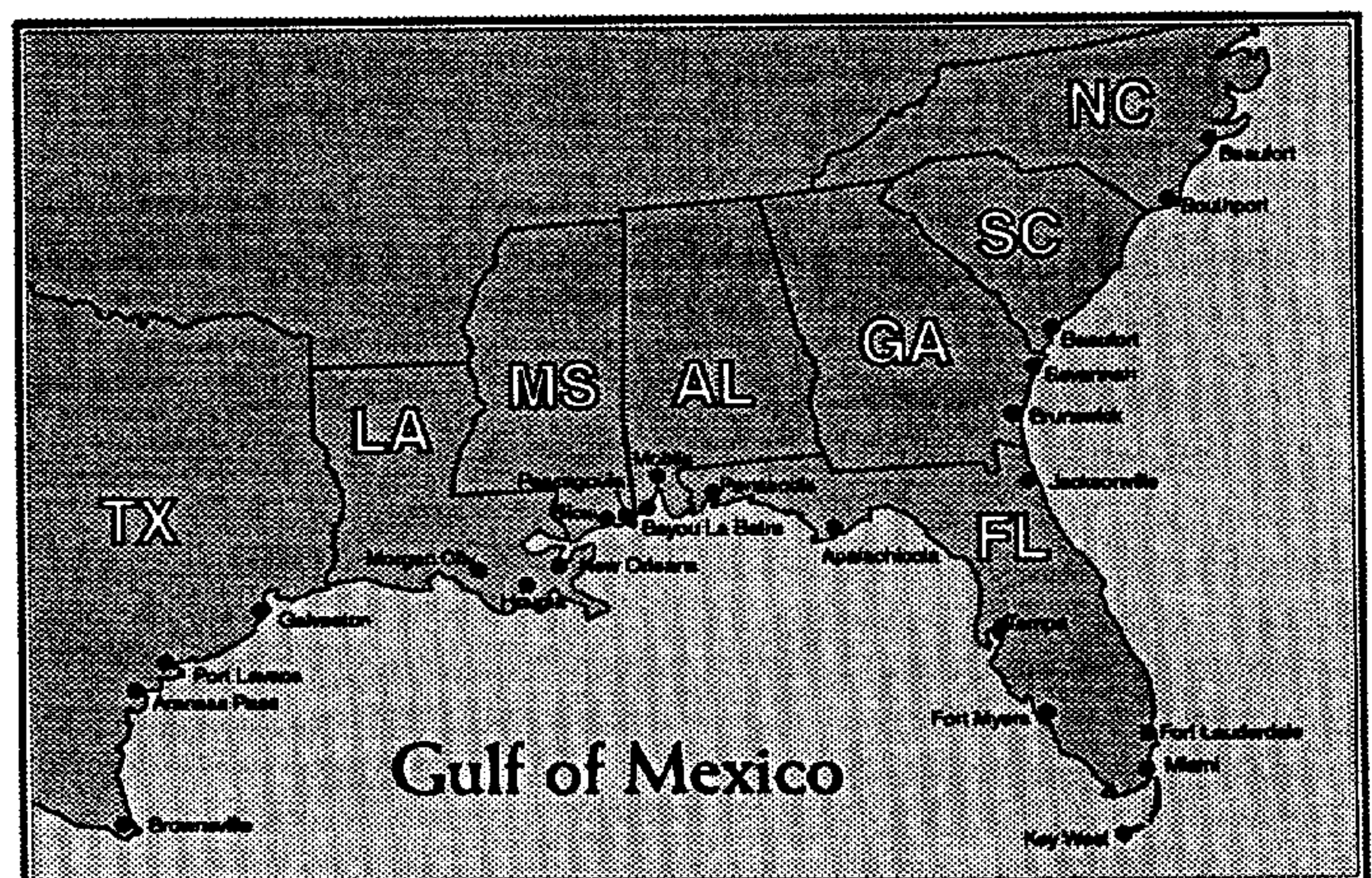
Source: NMFS, 1977

Turning to economic research, attention is being given to expanding shrimp CPUE and vessel costs and earnings data since they are vital ingredients in cost-benefit analyses. Bycatch characterization research has generated extensive information on shrimp catch rates and related information which allows researchers to determine how shrimp catch rates vary as a function of fishing area, season, depth, trawl gear variations, and vessel characteristics. Another major accomplishment has been the collection of an additional 3-6 years of shrimp vessel cost and earnings data for the Gulf of Mexico. With these new data, researchers are assembling what will soon be a relatively complete time-series of cost-earnings data for inshore and offshore vessels extending from 1969 to 1993.

When linked together, improved CPUE and cost earnings information greatly enhance the ability to estimate likely costs and benefits of proposed management actions. For example, researchers at Texas A&M University (Hendrickson and Griffin, 1993) used these data in conjunction with the general bioeconomic fishery simulation model (GBFSM) to examine the likely effects of using season/area closures and BRDs to reduce the bycatch of Atlantic croaker, red snapper, and king mackerel in the Gulf of Mexico shrimp fishery. Ultimately, the purpose was to estimate resulting economic impacts on shrimpers. Based on this analysis, Hendrickson and Griffin concluded that BRDs were far more effective than area/time closure for reducing bycatch of red snapper, croaker and king mackerel, and were less costly in terms of their effect on overall rent from the fishery. Notably, however, they found that BRDs also resulted in a more dramatic decline in number of vessels and days fished over the 10-year simulation period than did closures. The distribution of rent between vessel owners and crew also varied greatly as a function of the management option selected. Because of the significant interrelationships between the shrimp and reef fish fisheries, NMFS researchers are collecting cost and earnings data on the reef fish fishery so that the costs and benefits of bycatch management options can likewise be estimated for this fishery.

Development and Refinement of Bioeconomic Models

Significant progress has been made in developing and refining a bioeconomic model to help managers address the many complex issues involved in evaluating the likely impacts of bycatch reduction management measures on shrimp and reef fish fisheries. The complexity of the bycatch problem is revealed by the fact that directed sport and commercial fisheries exist for many of the finfish species frequently caught as bycatch in the shrimp fishery. Decisions regarding bycatch management options must be made based on an understanding of the benefits and costs that will accrue to the shrimp fishery as well as to other biologically impacted fisheries. Even fisheries that are not biologically impacted may still be affected if management measures displace fishermen from the shrimp fishery and they choose to enter these other biologically-unrelated fisheries (e.g., swordfish). Because of these complex relationships, bioeconomic models are needed that describe key biologically-affected fisheries (e.g., reef fish and mackerels) and which can account for inter-fishery transfers of effort, capital, and labor.

In response, NMFS and university researchers have developed a bioeconomic model which portrays the interrelationships between the Gulf of Mexico shrimp and reef fish fisheries (Ward, 1994). They are presently using recently collected shrimp cost/earnings data, bycatch CPUE information, and bioeconomic reef fish fishery data to tune this model so it reflects actual fishery conditions. When completed, this model will enable managers to evaluate the relative cost effectiveness of potential shrimp bycatch reduction management options.

Even though insufficient data exist at this point to precisely estimate the magnitude of costs and benefits produced by bycatch management options, preliminary analyses are providing useful insights regarding the nature and direction (positive or negative) of likely impacts in the shrimp and reef fish fisheries (Ward, 1994). For example, analyses of the possible impacts of required BRD use in the shrimp fishery shows that by themselves, BRDs may not produce long-term increases in the stock sizes for bycatch species. Instead, resulting short-term increases in abundance may be dissipated if commercial and recreational fishermen are allowed to increase their directed fishing effort on these species. These analyses also show that the true long-term magnitude of bycatch reduction will be determined by the shrimp retention rates of the BRD. If a BRD results in shrimp loss, the fleet will likely increase overall shrimping effort to compensate for this loss, thereby dampening the level of overall bycatch reduction. Last, the model demonstrates that bycatch management actions which increase the cost of harvesting shrimp (e.g., a landings tax or individual transferable quota) will also reduce shrimping effort and overall bycatch levels.

Development of Ecosystem Models

The last major area of research progress pertains to the development of a marine ecosystem model to help managers understand the impact of shrimp trawl bycatch on trophic level interactions and community structure. Effective bycatch reduction measures will reduce mortality of many affected species. However, some people are concerned that these measures will also release more predators of shrimp, allow small predators to grow larger, and in theory, impact shrimp stocks due to increased predation.

Trophic models are generally accepted as a valuable tool for evaluating predator-prey interactions in the shrimp fishery. The original model, developed in the early 1980's (Browder, 1983), simulates the Gulf ecosystem and has compartments representing different trophic groups linked by energy flow and nitrogen cycling within the system. This trophic model also provides flexibility for the inclusion of biotic and abiotic factors such as riverine input of nitrogen, solar radiation, plankton and benthic components, fishing effort, and stocks of shrimp, bottomfish, migratory and pelagic finfish, large predators, scavengers, and utilization of bycatch by fishermen.

A very simplified depiction
of Browder's Ecosystem
Model for the Northern
Gulf of Mexico
(NMFS 1995)
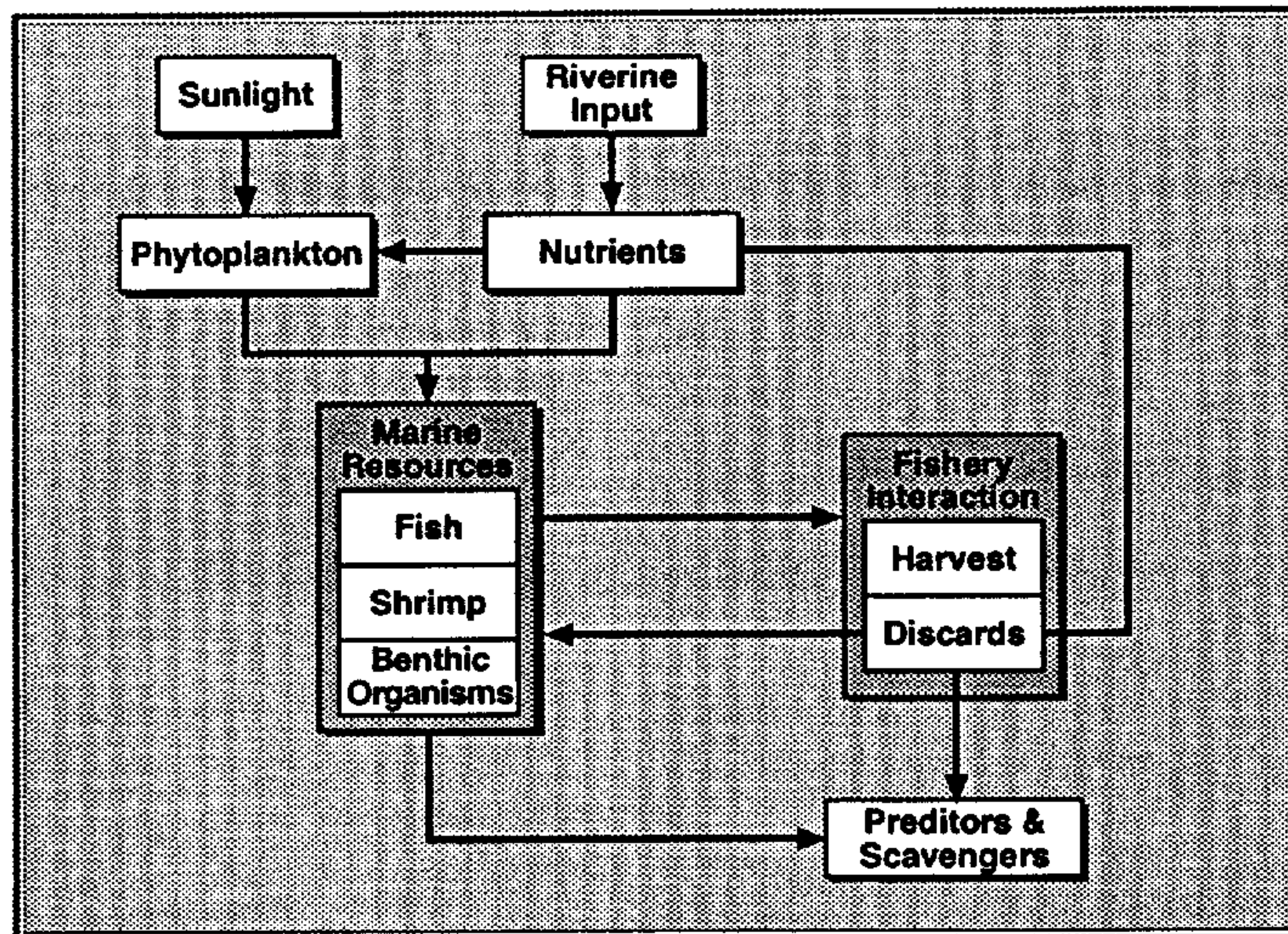
Research reported by Sheridan et al. (1984) evaluated the utility of this model for evaluating the impacts of reducing bycatch on shrimp production. The results from this model suggested that shrimp production (biomass) might theoretically decline by as much as 25 percent if 50 percent of all finfish bycatch was kept by fishermen and not returned to the system in the form of dead bycatch discards. However, model results also indicated that only an 8 percent reduction in shrimp production would occur with the introduction of trawl devices that reduced finfish mortality, especially if surviving finfish did not selectively prey upon shrimp. Consequently, the authors concluded that using BRDs or similar techniques to reduce finfish capture would result in no long-term effect on shrimp harvest, even if finfish exhibited moderate selectivity against shrimp as prey. Shrimp biomass (and yield) could decrease initially with the introduction of BRDs, but the shrimp stock would rebound and stabilize after the first or second year (Sheridan et al., 1984).

NMFS is currently revising and updating this trophic model to include new information on shrimp predator-prey interactions, characterization of bycatch species, and effects of bycatch reduction devices. Since April 1992, bycatch characterization studies have generated data on over 350 species of finfish including their size and weight characteristics, and CPUE by area, season, and depth fished. Initial BRD evaluations indicate that certain gear types can release up to 70 percent of fish by number. Seven species of known shrimp predators, representing 9.5 percent of the total finfish biomass, were ejected from trawls using BRDs. Among shrimp predators, CPUE was reduced for lane snapper, Atlantic croaker, Spanish mackerel, and to a lesser extent, red snapper. CPUE remained unchanged for rock sea bass, smooth puffer, and inshore lizardfish. The addition of these specific types of data, together with technological improvements in computer hardware and software, will make simulation runs of the new revised model more accurate.

Program Objective VI

Develop an Education and Information Transfer Program

Program Needs

Timely dissemination of accurate information to interested and affected parties is essential to address the critical and controversial nature of the bycatch problem and to assist in the rapid adoption of bycatch reduction approaches by the shrimp industry.

Research Actions

(1) Establish effective mechanisms to ensure involvement.

(2) Plan, implement, and oversee public and industry information and education activities.

(3) Organize and conduct workshops to transfer bycatch reduction technology to the shrimping industry.

Significant Accomplishments

Opening Doors for Involvement

From the outset, it has been clear that resolution of the shrimp trawl bycatch problem would require the involvement and cooperation of many diverse groups in planning and implementing the Bycatch Research Program. Further, since perception often drives policy, it also has been clear that program success would hinge on the timely dissemination of accurate information to this diverse array of affected and interested parties. Program partners have attempted to effectively address these two important requirements.

With respect to research program planning and implementation, care has been taken to establish an organization and process that is inclusive of all major user groups and builds on consensus. The GSAFDF played a central role in organizing diverse parties into a cohesive program planning and coordination body, the 34 member Bycatch Program Steering Committee. Program researchers have used the Steering Committee as the primary vehicle for apprising member organizations of program actions and accomplishments. These same organizations have likewise worked diligently to disseminate this information to their respective members and to other organizations and individuals with whom they interact.

A Sampling of Information Activities

Several program partners have made significant contributions to information and education goals by sponsoring local, regional, and even international workshops. Examples include a 2-day facilitated regional Shrimp Trawl Bycatch Workshop hosted by the Center for Marine Conservation in St. Petersburg, Florida in November 1991 (Center for Marine Conservation, 1992a). This privately funded workshop helped major stakeholders share their views and concerns about shrimp trawl bycatch in a practical and constructive way and to identify issues that

needed to be addressed in the research program. The Center also published a document entitled, "The Gulf Of Mexico Shrimp Fishery: Profile of a Valuable National Resource" (Center for Marine Conservation, 1992b). Its purpose was to create an improved public understanding of this important fishery ranging from shrimp biology to management challenges.

Exploring the issues at the CMC sponsored Shrimp Trawl Bycatch Workshop.
Photo courtesy of CMC.

The Southeastern Fisheries Association, a key commercial fishing organization, planned and held an International Conference on Bycatch in Lake Buena Vista, Florida in May, 1992. Conference organizers assembled an impressive group of researchers from the U.S. and abroad to explore the bycatch issue from both a technical and "public" perspective, and to learn how other countries were addressing the issue. One of the most enlightening aspects of the meeting was the information exchange regarding alternative shrimp harvest gear and methods (Southeastern Fisheries Association, 1992).

The Gulf and South Atlantic Fisheries Development Foundation also has sponsored a number of workshops to inform fishermen and other interested parties about the research program and related research findings. During 1993 and 1994, 13 industry workshops were held in locations from Texas to North Carolina and 27 presentations were made to science, management, and fishery groups. A number of press releases have been produced as well.

In January 1994, the University of Georgia Sea Grant Program sponsored a highly successful workshop on BRD development and research. This was probably the largest gathering of gear researchers convened to date by program cooperators.

Also of note, industry and government partners in the Southeast Shrimp Trawl Bycatch Research Program shared their knowledge and experience at the National Industry Bycatch Workshop on February, 1992, in Newport, Oregon (Natural Resources Consultants, 1992).

NMFS also has contributed to program education and technology transfer efforts. Numerous presentations have been given to diverse fisheries and conservation audiences regarding the Bycatch Research Program and specific research topics. In depth program briefings were presented to NOAA's Marine Fisheries Advisory Committee, the South Atlantic and the Gulf of Mexico Fishery Management Councils, and the National Fisheries Institute. Further, financial assistance awards totaling nearly $300,000 have been provided to states and others through the MARFIN and Saltonstall-Kennedy programs to assist in educational and technology transfer efforts.

Sharing knowledge about bycatch reduction devices at the docks.

With the significant strides that have been made in bycatch characterization and BRD development research, public education and outreach efforts will escalate in 1995 to share this information more broadly with commercial and recreational fishing interests, state and federal fishery managers, the conservation community, and the media. During its October 1994 meeting, the Bycatch Program Steering Committee agreed to organize an information and outreach subcommittee to develop a more detailed strategy for this expanded effort. Comprised of key federal, state, industry, and conservation community representatives, this subcommittee will likely engage a commercial public relations firm to assist in this important effort. Technology transfer regarding BRDs will be a major thrust.

✓Program Objective VII

Identify and Evaluate Other Sources of Fishing Mortality

Program Needs

Identification and quantification of other, non-bycatch related sources of fishing mortality for federally managed species are essential to accurately assess their stock status. Estimates of directed and incidental commercial and sportfishing harvest of these species need to be improved. Further, it is widely acknowledged that coastal development, pollution, and industrial water use also impose major negative impacts on estuaries and fish stocks. These non-fishery, but human-induced sources of mortality must also be characterized and where possible, quantified.

Research Actions

(1) Collect all available information on commercial and recreational fishing mortality for key species other than from shrimp fisheries in the Gulf and South Atlantic regions.

(2) Incorporate these mortality estimates into stock assessments for affected species.

Significant Accomplishments

Increasing What Is Known About Fishing Mortality

As a matter of standard protocol, stock assessment biologists attempt to quantify total fishing mortality with the highest degree of accuracy possible. Admittedly, some sources of fishing mortality can be only approximated. Overestimates typically lead to excessively restrictive management measures while underestimates may result in management measures that fail to adequately protect fisheries stocks. NMFS and state stock assessment scientists do not operate in a vacuum, they typically collaborate on assessments and invite other university and private sector experts into the process. In this fashion, they reduce the chance for significant error.

In addition to these procedures, progress continues to be made in filling gaps in the understanding of human-induced fish mortality (fishing and non-fishing). Marine recreational fishing in the southeastern U.S. is an outdoor recreation activity of growing popularity, economic significance, and consequence to marine fishery resources. Data from the NMFS 1992 Marine Recreational Fisheries Statistics Survey (NMFS, 1993) indicate that roughly 74 percent of all fish caught by anglers in the Region were not kept and landed, they reportedly were discarded dead, used for bait, or released alive. Information on unlanded catch is based totally on angler recall of their day's fishing and is susceptible to over- or underestimation. NMFS' Southeast Region has awarded Saltonstall-Kennedy funds to Texas Parks and Wildlife Department to evaluate current and optional methods for potentially improving these estimates of recreational bycatch. Relatively high priority also is being given to research designed to produce better estimates of hook-and-release mortality and to expand educational efforts designed to help anglers reduce waste and improve their catch-

and-release skills. All these efforts will help reduce fishing mortality in recreational fisheries.

Several other notable research projects are underway to characterize bycatch in commercial finfish fisheries in the South Atlantic and Gulf of Mexico. University and state researchers have been funded to examine bycatch in South Atlantic and Gulf longline fisheries, the Gulf menhaden fishery, and the South Carolina shad fishery. NMFS research efforts have focused on fish traps and bottom longlines used in the reef fish fishery. Information from these studies will be incorporated, as appropriate, into stock assessments for affected species.

NMFS researchers have started to investigate the extent of fish mortality caused by the removal of offshore oil and gas structures in the Gulf of Mexico. Current regulations require the removal of these structures at the end of their useful life, a process typically aided by the use of explosives. Given the large number of these structures in the Gulf (4,000 plus) and the important fish habitat functions they serve, fish mortality associated with their removal must be determined.

Last, there are sources of fish mortality worthy of critical investigation that are outside the means of this program. Entrainment mortality associated with electrical generation facilities has been estimated in both the published and grey literature and is significant. In this case, mortality occurs when eggs, larvae, juveniles, and in some cases, adult specimens of marine organisms are physically injured and killed by system cooling processes involving the intake of large volumes of coastal water. This issue needs further investigation and quantification to stimulate the implementation of effective solutions.

Program Objective VIII

Develop and Manage a Centralized Program Database

Program Needs

Given the size and cooperative nature of this research program, establishing a centralized data collection and management program is imperative. The Foundation's Finfish Bycatch Steering Committee suggested that the NMFS Galveston Laboratory have overall responsibility for assembling and managing the program database. Data collected by NMFS and non-NMFS observers would be archived at the Galveston Laboratory and all data requests should be processed through the database manager.

Research Actions

(1) Develop and manage a centralized bycatch characterization database at the NMFS Galveston Laboratory.

(2) Develop and manage a centralized BRD testing database at the NMFS Galveston Laboratory.

Significant Accomplishments

Development of a centralized bycatch characterization and BRD testing database was one of the first tasks to be accomplished in the Bycatch Research Program, and for several important reasons. First, before data collection could begin, standard protocols needed to be established to ensure expeditious entry, editing, processing, and retrieval of the large data set that would be generated by these research efforts. Second, time was even more of the essence since both NMFS and non-NMFS observers participating in this research had to be trained regarding standard data collection and management protocols. Third, since these data collection efforts are the cornerstone of the Research program, effective data collection and management protocols had to be implemented to ensure the integrity and utility of this database.

Observers recording catch information.

By agreement between all program cooperators, NMFS' Galveston Laboratory was assigned the responsibility of developing and managing the centralized bycatch database. A Bycatch Database Management Plan (SEFSC, 1992a) was subsequently developed and implemented with appropriate documentation of standardized data collection and management protocols. All observers were trained and certified in the use of these protocols prior to deployment on shrimp vessels.

For every tow sampled by an observer, seven files were created and loaded into the database documenting the following important aspects of the tow:

1) Descriptive information on the fishing vessel;
2) Detailed information on deployed shrimp trawl gear;
3) Detailed information on deployed TED/BRD gear;
4) Detailed sampling station information (location, depth, tow duration, etc.);
5) Catch composition (shrimp and bycatch species);
6) Length/frequency information on measured finfish;, and
7) Turtle sighting information.

All raw data sheets are submitted by observers to the database manager in Galveston for editing within 2 weeks of the completion of a cruise. Edited data are returned to the observer for final verification prior to being loaded into the database.

Currently, the database contains 17,843 records representing 2,549 sampled tows. Additional records are being entered as each new additional tow is sampled. Upon written request, raw data are made available to authorized researchers and managers for analysis and use. Only summarized information is provided to requestors lacking authorization to use confidential information.

Summary

Through the 1990 Amendments to the Magnuson Fishery Conservation and Management Act, Congress recognized the gravity of the shrimp trawl bycatch problem and mandated a research program to accurately characterize bycatch and its impact on federally managed fishery resources. Congress also called for the commencement of efforts to identify effective methods for reducing bycatch. Thanks to the combined cooperative efforts of many government and private organizations, a comprehensive research program addressing finfish bycatch in the South Atlantic and Gulf of Mexico shrimp trawl fisheries is well underway. From the outset, every possible effort has been made to be fully responsive to Congressional mandates regarding this effort. Some of the more significant features and accomplishments of this program merit emphasis:

- The program continues to be an inclusive cooperative effort with strong participation by the shrimp industry, states, universities, sportfishing interests, and the conservation community.

- There has been strict adherence to stringent scientific protocols by all cooperators.

- Available resources from many sources have been used to reduce the need for "new" funding.

- Bycatch characterization is nearly complete.

- Characterization data are already being incorporated into stock assessments for several key species.

- Social and economic impacts are being addressed.

- The bycatch reduction performance of grid-type TEDs has been evaluated and research to evaluate soft TEDS is underway.

- Several BRDs are being commercially tested that meet program performance criteria for red snapper bycatch reduction, with minimal shrimp loss.

Building on these accomplishments, research program emphasis will shift over the coming months in several ways. Bycatch characterization data will continue to be collected, but mainly as a secondary activity done in conjunction with larger-scale commercial testing of BRDs. The Gear Review Panel will continue to actively search for new BRD designs capable of meeting program finfish exclusion and shrimp retention goals. The Panel also will be reviewing TED bycatch reduction evaluation results and developing procedures for certification of BRDs.

Researchers and managers will escalate efforts to analyze characterization data to quantify bycatch and associated mortality for species of concern, and to identify alternative bycatch management strategies. In this regard, scientific panels likely will be convened to review

the results of these analyses and to address any continuing concerns about the research program. Associated with this, social and economic data collection and modeling efforts will proceed to support the effective evaluation of bycatch management proposals.

Finally, more formal and intensive information and education efforts will be implemented to expedite the broad dissemination of research findings and the transfer of bycatch reduction technology to the fishing community and other interested and affected parties. The timely dissemination of accurate information will play a pivotal role in our ability to effectively resolve this important problem.

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Appendix I

Shrimp Fishery Finfish Bycatch Program
Steering Committee

Steering Committee Chairman	Walter L. Shaffer (Gulf & S. Atlantic Fisheries Development Foundation)
Gulf & S. Atlantic Fisheries Development Foundation, Inc.	Steve Branstetter, Bycatch Program Coordinator Judy Jamison, Executive Director
Industry Representatives	Wilma Anderson (Texas Shrimp Association) Jane Black (Organization of Louisiana Fishermen) Bill Chauvin (American Shrimp Processors Association) Jack D'Antignac (Georgia Fishermens Association) David Hardee (Standard Marine Supply) Jan Harper (B&H Shrimp Company) John Hoey (National Fisheries Institute) Bob Jones (Southeastern Fisheries Association) Tee John Mialjevich (Concerned Shrimpers of America) Chris Nelson (Bon Secour Fisheries) Jerry Schill (North Carolina Fisheries Association, and the Foundation) Darcy Kiffe (Louisiana Shrimp Association)
Conservation Community	Ellen Peel (Center for Marine Conservation)
Sport Fishing Interests	Joe Detyens (Atlantic Coast Conservation Association) Bob Shipp (Gulf Coast Conservation Association)
Sea Grant Representatives	Mike Hightower (Texas A&M University) Mac Rawson (University of Georgia)
National Marine Fisheries Services	Brad Brown (Southeast Fisheries Science Center) Jim Nance (Galveston Laboratory) Scott Nichols (Mississippi Laboratories) Wil Seidel (Pascagoula Laboratory) Andrew Kemmerer (Southeast Regional Office) Ron Schmied (Southeast Regional Office)
Fishery Management Councils	Bob Mahood (South Atlantic Fishery Management Council) Wayne Swingle / Albert King (Gulf of Mexico Fishery Management Council)
Atlantic States Marine Fisheries Commission	Jack Dunnigan
Gulf States Marine Fisheries Commission	Larry Simpson
State Resource Agencies	Bill Hogarth (NC) William (Corky) Perret (LA) Ralph Rayburn (TX) David Whitaker (SC)

Technical Review Panel

Gulf & South Atlantic Fisheries Development Foundation, Inc.	Steve Branstetter, Coordinator
Working Group Leaders	Jane Black (Organization of Louisiana Fishermen) Bill Chauvin (American Shrimp Processors Association) Ron Schmied (National Marine Fisheries Service) Larry Simpson (Gulf States Marine Fisheries Commission)
Biological Research	Richard Condrey (Louisiana State University) Nelson Ehrhardt (University of Miami) Robert Muller/Joseph O'Hop (Florida Department of Environmental Protection) Jim Nance (National Marine Fisheries Service) Arvind Shah (University of South Alabama) Charles Wenner (South Carolina Wildlife & Marine Resources Division)
Gear Technology	Gary Graham (Texas A&M University) Dave Harrington (University of Georgia Sea Grant) Jim Murray (University of North Carolina Sea Grant) Wil Seidel (National Marine Fisheries Service)
Sociology and Economics	Robert Ditton (Texas A&M University) Michael Orbach (East Carolina University) Ken Roberts (Louisiana State University)

✔Appendix II

Federally Funded Bycatch Research Projects

Bycatch Characterization

Title: Patterns in the Distribution and Abundance of Fishes and Macroinvertebrates in a Louisiana Marsh: Shrimp Bycatch in Inshore, Fishery-Independent Trawl Samples.
Grant Number: NA17FF0263-01   **Funding:** $32,162.00
Investigator: Dr. Donald Baltz - Louisiana State University
Dates/Status: 10/01/91 - 12/31/92 / Completed

Title: Development of Statistical Methods to Incorporate Uncertainty of Bycatch in Stock Assessment Methods of Directed Finfish Fisheries
Grant Number: NA27FD0072-01   **Funding:** $36,452.00
Investigator: Judy Jamison - Gulf & South Atlantic Fisheries Development Foundation
Dates/Status: 04/01/92 - 04/30/93 / Completed

Title: Shrimp Trawl Fishery Bycatch Characterization Study
Grant Number: 93NMFS20   **Funding:** $500,098
Investigator: Dr. James Nance - NMFS SEFSC Galveston Laboratory
Duration/Status: 10/01/92 - 9/30/93 / Completed

Title: Spatial and Temporal Patterns in the Distribution and Abundance of Fishes and Macroinvertebrates in Coastal LA: Shrimp Bycatch Species in Fishery-Independent Trawl Samples
Grant Number: NA37FF0051-01   **Funding:** $44,074.00
Investigator: Dr. Donald Baltz - Louisiana State University
Duration/Status: 03/01/93 - 02/28/94 / Completed

Title: Shrimp Bycatch Characterization Research
Grant Number: 94MFIH08   **Funding:** $249,980.00
Investigator: Dr. James Nance - Galveston Laboratory
Duration/Status: 10/01/93 - 09/30/94 / Completed

Title: Spatial and Temporal Patterns in the Distribution and Abundance of Fishes and Macroinvertebrates in Coastal LA: Shrimp Bycatch Species in Fishery-Independent Trawl Samples
Grant Number: NA37FF0044-02   **Funding:** $44,465.00
Investigator: Dr. Donald Baltz - Louisiana State University
Duration/Status: 03/01/94 - 02/28/95 / Active

Title: Early Life History and Relative Abundance of Blacktip and Other Coastal Sharks in Eastern Gulf of Mexico Nursery Area, Including Bycatch Mortality of Sharks and Associated Fishes
Grant Number: NA57FF0034-01   **Funding:** $83,164.00
Investigator: Dr. Robert E. Hueter - Mote Marine Laboratory
Duration/Status: 11/01/94 - 10/31/95 / Active

Title: Florida Inshore Bait Shrimping; Experimental Analysis of Bycatch Exclusion and Capture-Related Mortality of Selected Seagrass-Associated Finfish Species
Grant Number: NA57FF0048-01   **Funding:** $61,053,00
Investigator: Dr. Felicia Coleman - Florida State University
Duration/Status: 12/01/94 - 11/30/95 / Active

Title: Assessment of Composition and Magnitude of Bycatch Associated with the Commercial Shrimp Trawling Industry in Central and Lower Texas Coastal Bays During the Spring and Fall TX Commercial Bay-Shrimp Open Seasons
Grant Number: NA37FD0083-01   **Funding:** $38,726.00
Investigator: Billy Fuls - Texas Parks & Wildlife Department
Duration/Status: 06/01/93 - 05/31/94 / Completed

Title: Assessment of Composition and Magnitude of Bycatch Associated with the Commercial Shrimp Trawling Industry on the Northern and Mid Texas Coast During Spring and Fall Texas Commercial By-Shrimp Open Seasons.
Grant Number: NA47FD0291   **Funding:** $65,742.00
Investigator: Billy Fuls - Texas Parks & Wildlife Department
Duration/Status: 04/01/95 - 03/31/96 / Active

BRD Development

Title: Development and Evaluation of Finfish Separator Device and TEDS Combinations to Reduce Bycatch in the Shrimp Fishery
Grant Number: NA17FD0101-01   Funding: $40,653.00
Investigator: James D. Murray - North Carolina State University
Duration/Status: 04/01/91 - 09/30/92 / Completed

Title: Introduction of the Skimmer Trawl to Reduce Bycatch and Incidental Capture of Sea Turtles in Inshore Waters
Grant Number: NA17FD0104-01   Funding: $57.447.00
Investigator: James D. Murray - North Carolina State University
Duration/Status: 05/01/91 - 07/31/92 / Completed

Title: Feasibility Study Finfish Excluding Gear in Shrimp Trawls in the Western Gulf of Mexico Bycatch
Grant Number: NA17FF0374-01   Funding: $95,000.00
Investigator: Wilma Anderson - Gulf Shrimp Research & Development Foundation
Duration/Status: 10/01/91 - 09/30/92 / Completed

Title: Evaluation of Shrimp Trawls Designed to Reduce Bycatch in Inshore Waters of Louisiana
Grant Number: NA17FF0375-01   Funding: $46,917.00
Investigator: Barton Rogers - Louisiana State University
Duration/Status: 11/01/91 - 10/31/92 / Completed

Title: Gear Development to Reduce Bycatch in the North Carolina Trawl Fisheries
Grant Number: 9X2NA90AAHSK052   Funding: $113,054.00
Investigator: Judy Jamison - Gulf & South Atlantic Fisheries Development Foundation
Duration/Status: 11/01/91 - 10/31/92 / Completed

Title: Reduction of Finfish Capture in South Atlantic Shrimp Trawls - Bycatch
Grant Number: NA27FD0070-01   Funding: $76,445.00
Investigator: David L. Harrington - University of Georgia
Duration/Status: 03/01/92 - 08/31/93 / Completed

Title: Shrimp Trawl Bycatch Reduction
Grant Number: 93NMFS18   Funding: $400,000.00
Investigator: Watson, Nance, and Seidel - Mississippi Laboratory
Duration/Status: 10/01/92 - 09/30/93 / Completed

Title: Evaluation of Shrimp Trawls Designed to Reduce Bycatch Inshore Waters of Louisiana
Grant Number: NA17FF0375-02   Funding: $47,150.00
Investigator: Barton Rogers - Louisiana State University
Duration/Status: 11/01/92 - 10/31/93 / Completed

Title: Shrimp Trawl Bycatch Reduction
Grant Number: 94MFIH10   Funding: $425,000.00
Investigator: Seidel, Watson, and Nance - Mississippi Laboratory
Duration/Status: 10/01/93 - 09/30/94 / Completed

Title: A Program to Distribute and Evaluate Bycatch Reduction Devices in Inshore Waters of NC
Grant Number: NA37FF0038-01   Funding: $48,524.00
Investigator: James D. Murray - North Carolina State University
Duration/Status: 04/01/93 - 03/31/94 / Completed

Title: Development and Classification of Devices for Use in South Atlantic Shrimp Trawls and to Classify Them by Size; to Enhance BRD Technology Transfer within the Commercial Fisheries of the Region
Grant Number: NA47FF0010-01   Funding: $109,494.00
Investigator: David L. Harrington - University of Georgia
Duration/Status: 11/01/93 - 10/31/94 / Completed

Title:	Evaluation of Trawl Efficiency Devices/Bycatch Reduction Devices in Estuarine and Nearshore Waters of North Carolina
Grant Number:	NA47FF0016-01 Funding: $152,110.00
Investigator:	Sean McKenna - North Carolina Department of Environment, Health & Natural Resources
Duration/Status:	04/01/94 - 03/31/95 / Active

Title:	The Texas Shrimp Industry Salt-Box Catch Separation Procedure Effect on Bycatch Survival
Grant Number:	NA57FF0047-01 Funding: $37,189.00
Investigator:	Robert L. Colura - Texas Parks & Wildlife Department
Duration/Status:	12/01/94 - 11/30/95 - Active

Title:	The Behavior of Fish and Shrimp in Relation to Trawl Modifications to Reduce Shrimp Trawler Bycatch
Grant Number:	NA57FF0049-01 Funding: $43,665.00
Investigator:	Donna Rogers - Louisiana State University
Duration/Status:	01/01/95 - 12/31/95 / Active

Title:	Introduction of Larger Mesh Webbing in the Belly and Wings of Traditional Shrimp Trawls to Reduce Bycatch in Inshore Waters
Grant Number:	NA37FD0088-01 Funding: $60,148.00
Investigator:	James D. Murray - North Carolina State University
Duration/Status:	06/01/93 - 05/31/94 / Completed

Title:	The Leatherback Turtle situation will be Addressed by using TED Evaluation Techniques to Introduce to the Commercial Fishing Industry New TED Designs by Assessing Their Shrimp Retention and Bycatch Exclusion Rates as Compared to Conventional TEDS.
Grant Number:	NA57FD0033 Funding: $53,557.00
Investigator:	David L. Harrington - University of Georgia
Duration/Status:	11/01/94 - 10/31/95 / Active

Title:	Reduction of Bycatch in North Carolina Otter Trawl Fisheries
Grant Number:	NA47FD0298 Funding: $64,136.00
Investigator:	James Monaghan, Jr. - North Carolina Department of Environment, Health & Natural Resources
Duration/Status:	12/01/94 - 05/31/96 / Active

Title:	Skimmer Trawl Modifications to Reduce Bycatch in the Inshore Brown and Pink Shrimp Fishery in North Carolina
Grant Number:	NA47FD0299 Funding: $55,742.00
Investigator:	Dr. James Murray - North Carolina State University
Duration/Status:	03/01/95 - 02/28/96 / Active

Multiple Objectives

Title:	Strategic Planning, Data Collection, and Gear Evaluation for the Management of Bycatch in the Directed Commercial Fisheries of the Gulf of Mexico
Grant Number:	NA17FF0233-01 Funding: $109,660.00
Investigator:	Judy Jamison - Gulf & South Atlantic Fisheries Development Foundation
Duration/Status:	05/01/91 - 01/31/93 / Completed

Title:	Organization and Management of a Gulf of Mexico and South Atlantic Ocean Fishery Bycatch Management Program
Grant Number:	NA17FD0103-01 Funding: $357,604.00
Investigator:	Judy Jamison - Gulf & South Atlantic Fisheries Development Foundation
Duration/Status:	05/01/91 - 01/31/93 / Completed

Title:	Bycatch Allocation
Grant Number:	92NMFS Funding: $1,139,000.00
Investigator:	Dr. Bradford Brown - Southeast Fisheries Center
Duration/Status:	10/01/91 - 09/30/92 / Completed

Title: Bioeconomic Characterization of the Commercial Shrimp Trawler Bycatch Landed in McClellanville, SC and Socioeconomic Description of Local Bycatch Consumers
Grant Number: NA17FD0109-01   **Funding:** $57,447.00
Investigator: Paul M. Scholz - University of South Carolina
Duration/Status: 05/01/91 - 03/31/92 / Completed

Title: Bio-socio-economic Characterization of the Commercial Shrimp Trawler Bycatch Landed in South Carolina and the Effect of Juvenile Mackerel Mortality Caused by the Trawls on the Stock of Adult Mackerel Stocks
Grant Number: NA27FD0067-01   **Funding:** $62,129.00
Investigator: Dr. John Dean - University of South Carolina
Duration/Status: 04/01/92 - 03/31/93 / Completed

Title: Florida Inshore Shrimping: Experimental Analysis of Bycatch Reduction and a State-Wide Bycatch Survey
Grant Number: NA37FF0051-01   **Funding:** $139,772.00
Investigator: Dr. Felicia Coleman - Florida State University
Duration/Status: 03/01/93 - 08/31/94 / Completed

Title: Continued Implementation of High Priority Objectives Outlined in a Gulf of Mexico and South Atlantic Shrimp Fishery Bycatch Research Program
Grant Number: NA47FF0007-01   **Funding:** $297,549.00
Investigator: Dr. Steven Branstetter - Gulf & South Atlantic Fisheries Development Foundation
Duration/Status: 11/01/93 - 10/31/94 / Completed

Title: Organization & Management of Gulf of Mexico and South Atlantic Ocean Fishery Bycatch management Program (Year II)
Grant Number: NA37FD0032-01   **Funding:** $600,000.00
Investigator: Judy Jamison - Gulf & South Atlantic Fisheries Development Foundation
Duration/Status: 11/01/92 - 04/30/94 / Completed

Title: Final Implementation of High—Priority Objectives of a Bycatch Reduction Research Program for the Gulf of Mexico and South Atlantic Shrimp Fishery
Grant Number: NA47FD0301   **Funding:** $601,725.00
Investigator: Dr. Steve Branstetter - Gulf & South Atlantic fisheries Development foundation
Duration/Status: 05/01/95 - 04/30/96 / Active

Social and Economic Research

Title: Potential for Reduction of Shrimp Trawl Bycatch of Selected Finfish Species in the Gulf of Mexico
Grant Number: NA17FL0099-01   **Funding:** $56,139.00
Investigator: Dr. Wade Griffin - Texas A&M Research Foundation
Duration/Status: 07/01/91 - 08/31/92 / Completed

Title: Economic Analysis of Finfish Bycatch in the Gulf Shrimp Fishery
Grant Number: 92NMFS11   **Funding:** $101,000.00
Investigator: Dr. John Ward - Southeast Regional Office
Duration/Status: 10/01/91 - 09/30/92 / Completed

Title: Decision-Making by Shrimp Fishermen as Reasoned Action: Behavioral Determinants of Bycatch Characteristics and Projected Effects of Bycatch Regulations on Labor Decisions
Grant Number: NA37FF0049-01   **Funding:** $100,000.00
Investigator: Dr. Stephen Thomas - University of South Alabama
Duration/Status: 04/01/93 - 03/28/94 / Completed

Title: Estimation of Real Effort in the Heterogeneous Gulf Shrimp Fleet (Bycatch)
Grant Number: NA37FF0053-01   **Funding:** $76,731.00
Investigator: Dr. Wade Griffin - Texas A&M Research Foundation
Duration/Status: 04/01/93 - 03/31/94 / Completed

Title:	Investigation of the Basic Bioeconomic Dynamics of Bycatch Problems in Gulf of Mexico Fishery Management
Grant Number:	NA27FD0068-01 Funding: $10,601.00
Investigator:	Seth Macinko
Duration/Status:	06/01/92 - 05/31/93 / Completed.

Title:	Decision-Making by Shrimp Fishermen as Reasoned Action: Behavioral Determinants of Bycatch Characteristics and Projected Effects of Bycatch Regulations on Labor Decisions
Grant Number:	NA37FF0049-02 Funding: $201,643.00
Investigator:	Dr. Stephen Thomas - University of South Alabama
Duration/Status:	04/01/94 - 03/31/95 / Active

Title:	Shrimp Bycatch Reduction Impacts on the Harvesting, Processing and Community Sectors in the Gulf of Mexico
Grant Number:	NA57FF0050-01 Funding: $25,000.00
Investigator:	Dr. Wade Griffin - Texas A&M Research Foundation
Duration/Status:	06/01/95 - 05/31/96 / Active

Information and Education

Title:	An International Conference on the Reduction of Bycatch in Shrimp Trawling Operations and Alternative Harvesting Methods for the Shrimp Fishery
Grant Number:	0X2NA90AAHMF745 Funding: $99,650.00
Investigator:	Robert Jones - Southeast Fisheries Association, Inc.
Duration/Status:	11/01/91 - 03/31/93 / Completed

Title:	Improved Methods and Procedures for the Transfer of Technology and the Education of Constituency Groups for Devices that will Reduce the Fish Bycatch in Shrimp Trawls
Grant Number:	NA57FF0051-01 Funding: $32,231.00
Investigator:	David L. Harrington - University of Georgia
Duration/Status:	12/01/94 - 11/30/95 / Active

Other Sources of Mortality

Title:	Analysis of the Longline fishery Effort, Catch, & Bycatch in the SW Atlantic & Gulf
Grant Number:	NA37FF0040-01 Funding: $29,833.00
Investigator:	Dr. James Powers - Louisiana State University
Duration/Status:	05/01/93 - 09/30/94 / Completed

Title:	Bycatch in the U.S. Gulf of Mexico Menhaden Fishery
Grant Number:	NA47FF0020-01 Funding: $85,939.00
Investigator:	Dr. Richard Condrey - Louisiana State University
Duration/Status:	01/01/94 - 12/31/94 / Active

Title:	Characterization of Finfish Bycatch of Private Boa Recreational Anglers in TX Marine Waters
Grant Number:	NA37FD0084-01 Funding: $24,613.00
Investigator:	Dr. Ted Storck - Texas Parks & Wildlife Department
Duration/Status:	06/01/93 - 05/31/94 / Completed

Title:	Bycatch of Atlantic and Shortnose Sturgeons in the SC Shad Fishery
Grant Number:	NA37FD0080-01 Funding: $68,216.00
Investigator:	Dr. Mark Collins - South Carolina Wildlife & Marine Resources Department
Duration/Status:	08/01/93 - 09/30/94 / Completed

Title:	Bycatch of Atlantic and Shortnose Sturgeons in the South Carolina Shad Fishery
Grant Number:	NA47FD0293 Funding: $66,900.00
Investigator:	Dr. Mark Collins - South Carolina Wildlife & Marine Resources Department
Duration/Status:	10/01/94 - 09/30/95 / Active

Appendix III

Bycatch Reduction Device Development & Testing Protocol

(Excerpted from "Shrimp Trawl Bycatch Research Requirements,"
National Marine Fisheries Service, 1991)

Development of finfish reduction designs should be approached in two ways. One is to improve the finfish reducing capability of certified TEDs. The second is the development of new designs and modifications which can accomplish finfish separation more efficiently through simpler more cost effective approaches. Ultimately TEDs and bycatch reduction devices (BRDs) may have to be integrated into a single trawl design.

TED Evaluations

Considerable finfish catch data from offshore trawling have been collected on grid-style TEDs (NMFS, Georgia Jumper, and the mini supershooter). The Georgia Jumper and mini supershooter exhibit little (less than 10 percent) finfish reduction (NMFS Galveston Laboratory 1991). The NMFS TED, however, has an overall reduction rate of about 50 percent for day and night shrimping combined when tested against a standard net (Watson, 1986). Reduction rates for different species and different sizes of individuals vary. Limited data on the reduction rates of key species such as red snapper and mackerel exist. Undocumented reports on soft TEDs indicate finfish reduction rates of 50 percent or more. More data are needed to evaluate exclusion rates for species and size ranges of individuals. Key species are a primary consideration because red snapper, for example, are vulnerable to shrimp trawls in their first two years or juvenile stages only. In general, the smaller the size of the fish, the more difficult it is to exclude from a trawl. Most certified TED designs may not be very effective in removing small red snapper, for example.

One objective of BRD studies is to determine the effectiveness of certified TEDs in reducing finfish catch when compared with trawls without TEDs. Eight TED designs have been certified. To collect information on the finfish exclusion characteristics of each certified TED, observers should be placed on chartered and cooperative commercial vessels to document catch rates of key finfish species. During testing, tow times will be limited to 40 minutes in the summer and 60 minutes in the winter per recommendation of the National Academy of Science (National Academy of Science, National Research Council 1990).

The catch rate of red snapper, Spanish mackerel and king mackerel for each TED type can be compared with a standard trawl using a paired t-test. A standard trawl must be unmodified for the TED comparisons. The null and alternative hypotheses to be tested are:

$$H_0 : \mu_{STD} - \mu_{TED} = 0$$

$$H_A : \mu_{STD} - \mu_{TED} \neq 0$$

where μ_{STD} and μ^{TED} are the catch rates (mean catch) of any key species in the standard and TED nets. Testing should be conducted at trawl sites located where the key species are abundant. These areas can be determined using SEAMAP survey data. Approximately 20 tows are required to detect differences between nets. The number of required tows is estimated assuming a normal distribution, a confidence level of 97 percent (a = 0.03) and an error (e) of 0.05 as:

$$n \approx \frac{(Z_{a/2})^2 \sigma^2}{e}.$$

The standard deviation (s) is estimated based on the expected range of reduction of 0.35 to 0.75 as:

$$\sigma \approx RANGE/4.$$

More tows may be required if the difference between the catch in the standard net and the TED net is small.

New Designs and Modifications

Gear modifications that reduce finfish catches with minimum shrimp loss can be developed, but only through a thorough understanding and application of gear/shrimp/fish behavior interactions. Significant differences in the behavior and stamina of different species and different sizes of individuals exist. Fish reactions to trawling gear are determined by water flow in the trawl, water clarity, light levels, and component contrast. Gear modifications can probably be designed utilizing visual, mechanical, and/or auditory stimuli to effectively separate species from the net. Watson (1987) prepared a literature review of fish responses to trawling gear. Design of effective gear modifications at our present level of technical understanding is a trial-and-error process, where gear is first designed around some behavioral fish response and then evaluated for fish separation performance and shrimp loss. New gear designs and modifications will focus on red snapper, Spanish and king mackerel. Reduction rates will be evaluated by weight and number of fish to determine effectiveness.

A four-phase development program for new designs and modifications of existing shrimp trawl gear is proposed. Throughout the development process, each step will be coordinated with the Foundation's Technical Monitoring Committee. The four phases are:

1. Initial Design and Prototype Development - The full technical range of trawl design and modification approaches will be identified. Industry techniques, ideas solicited from fishermen, net shop designs, and research studies conducted by NMFS or other research groups around the world will be evaluated. Fish behavior, gear interaction and gear performance studies will be conducted on each design using scuba, acoustic instrumentation, and remote video cameras. This work will evaluate fish behavior and feasibility of concept. Throughout this phase, close cooperation will be necessary between the designer and the research group developing the prototype. Results during this stage of development must be subjectively evaluated based on the experience and expertise of the designer and research team. Operational data will be taken on the modified net, but preliminary catch performance data will be obtained during comparative gear trials. Once a design has been determined to offer potential and effectively integrated into the construction of a net, the second phase of development will be conducted.

2. Proof of Concept - Objectives during this phase will be to evaluate prototype devices on key species, determine finfish reduction rates, and establish shrimp catch rates. Proof of concept testing will also evaluate adequacy of design for safety and for problems with operational use. Testing will be in two parts: (a) tests with BRD versus a standard trawl, and (b) tests with BRD/TED gear combinations versus a standard trawl. A BRD must reduce bycatch by a minimum of 35 percent to be accepted as an adequate design. If the BRD passes the first experimental criterion, the second set of experiments will be conducted using BRD/TED gear combinations. The TEDs used during these experiments will be those most commonly used by commercial shrimpers. An acceptance criterion of a 50 percent bycatch reduction for any BRD/TED combination will be required before advancing to the third phase of operational testing under commercial fishing conditions. If the device fails in any one of the design characteristics or gear comparison experiments, it will undergo redesign and proof of concept testing will be repeated until the problem is either corrected or the approach is abandoned.

Gear comparison experiments will be conducted aboard either chartered commercial vessels or research vessels in areas where key finfish species are known to be present. The standard trawl for all tests will not contain any TED or BRD, and tow times will be limited to 40 minutes in the summer and 60 minutes during winter. Paired t-tests will be used to compare the catch rates of key species between the trawl with the BRD or BRD/TED and the standard trawl. The null and alternative hypotheses tested for the first set of experiments are:

$$H_0 : 0.65\mu_{STD} - \mu_{BRD} < 0$$

$$H_A : 0.65\mu_{STD} - \mu_{BRD} \geq 0$$

where μ_{STD} and μ_{BRD} are the catch rates (mean catch by number and weight) of any one of the key species in the standard net and the net with the BRD. The experiment will determine if the bycatch reduction device will reduce finfish catch of key species by 35 percent when compared with a standard net.

The null and alternative hypotheses tested for the second set of experiments are:

$$H_0 \; : \; 0.50\mu_{STD} - \mu_{BRD/TED} < 0$$

$$H_A \; : \; 0.50\mu_{STD} - \mu_{BRD/TED} \geq 0$$

where μ_{STD} and $\mu_{BRD/TED}$ are the catch rates (mean catch) of any one of the key species in the standard net and the net with the bycatch reduction device and TED. The experiment will determine if the BRD/TED combination will reduce finfish catch of key species by 50 percent when compared with a standard net.

The number of trawl hauls (sample size) required to test each device or modification at a specified confidence level and error level was estimated by using the expected range of bycatch reduction to estimate a standard deviation, and by assuming a normal distribution. The sample sizes required for various confidence levels were:

Confidence Level	No. of Tows
95.0 percent	16
97.5 percent	20
99.0 percent	27

During proof of concept evaluations, 20 tows will be obtained on each specific test.

Following proof of concept testing, devices with favorable results will be reviewed with the Foundation's Technical Monitoring Committee. Once the committee concurs, the prototype devices will be released to the commercial shrimping industry for operational evaluation on shrimp grounds throughout the southeast.

3. Operational Evaluation - The main objective in this phase is to test the BRD/TED gear combination under conditions encountered during commercial shrimping operations. Observers will be placed aboard cooperating commercial vessels to collect data on finfish catch rates and species composition. A BRD/TED combination will be tested on trawlers using the same TED employed in the test gear. Testing should be conducted over a wide range of geographic areas, seasons, and conditions. Tow durations will not be limited. The number of tows required to test each BRD/TED combination will be determined from the data collected during proof of concept testing. The null and alternative hypotheses tested will be similar to the hypotheses tested for proof of concept tests, except that a reduction standard of 50 percent will apply.

4. Industry Evaluation - The commercial shrimping industry will be responsible for fleet testing of candidate BRDs. Vessels should use the test devices on commercial shrimp grounds and maintain log books on results. Total finfish and total shrimp catches will be recorded for test nets and standard nets on at least 1 tow per day. Observers will be placed on a subset of vessels whose captains agree to keep log books to collect bycatch data by species. Finfish reduction contributed by the particular design of BRD/TED combination used on the vessel will be credited using rates established during controlled TED/BRD testing.

Appendix IV

Gear Review Panel Members

Dr. Steven Branstetter	Gulf & South Atlantic Fisheries Development Foundation
Mr. Steven Charpentier	Louisiana Shrimp Industry
Mr. Gary Graham	Texas A&M Sea Grant Program
Mr. Dave Harrington	University of Georgia Sea Grant Program
Dr. James Murray	University of North Carolina Sea Grant Program
Mr. Charles Oravetz	NMFS Southeast Regional Office, Protected Species Branch
Mr. Wil Seidel	NMFS Southeast Fisheries Science Center, Harvesting Systems Division
Mr. Carroll Yeomans	North Carolina Shrimp Industry